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Better Methods of Seeding Meadows

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The Northwestern Experiment Farm at Holgate was, until July, 1936, conducted cooperatively by the Department of Agronomy of the Ohio Station and the Division of Forage Crops and Diseases of the United States Department of Agriculture, and the data from Holgate reported in this bulletin were obtained through such cooperation.

BETTER METHODS OF SEEDING MEADOWS

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The heart of the rotation on any farm is its sod crops, especially its legume crops. This has been known and taught for years, but many events recently have brought this fact home to us as never before. The newer discoveries in dairy cattle feeding have put more and more emphasis on the value of forage of high quality in economical milk production and in preserving the health of the animal. The tremendously increased concern over the problem of soil erosion has shown that the basic method of erosion control is to keep as much of the land as possible under a vegetative cover; and on croplands, that means a good forage sod. Even on lands which are not greatly subject to erosion, the growing of grain crops causes a steady reduction in the crop-producing power of the soil which is due in part to, and associated with, the reduction of its content of organic matter (8)[4]. The only feasible way to replenish this organic matter is to put a larger proportion of the land into sods of legumes or legume mixtures.

High-grade legume sods, therefore, are the salvation of the farm and the foundation of its prosperity. With them, the farm continues to produce and prosper; without them, it is on the road to failure and decay.

These facts are not new; why, then, do we not have more uniformly good meadows? It would seem that the bottleneck of the problem is the difficulty of obtaining good stands of forages. Nothing is more common than to hear of failures of forage seedings, and these failures have occurred at a constantly increasing rate in recent years.

With no other important crop is failure to obtain a stand accepted as a frequent and almost inevitable hazard in the culture of the crop. Indeed, it is a testimony of the extent to which farmers appreciate the importance of these crops that they continue to sow clover and other legumes in the face of repeated failures to obtain stands. Any program of increasing the proportion of land in soil-building sod crops must, first of all, attack the problem of obtaining seedings.

Because of the vital importance of this problem, an important part of the experimental work of the Department of Agronomy during the last 10 years has consisted of tests at Wooster, Columbus, and the outlying experiment farms, designed to study the principles involved in obtaining seedings.

ARE GOOD STANDS BECOMING LESS CERTAIN?

Definite statistical evidence is lacking, but it seems clear that failures in obtaining stands are becoming more frequent with each decade. This would be expected on many farms as a result of soil deterioration (8). An important factor in the increasing failure of seedings is the steady depletion of the organic matter in the soil. This brings about poor physical condition of the soil, which is often fatal to forage seedings. Poor soils cause poor sods, and poor sods permit the soils to become poorer.

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On the other hand, on many farms higher yielding varieties of the small-grain crops, better cultural practices, and the increasing use of commercial fertilizer and lime all contribute to larger yields of both grain and straw. These larger yields of small-grain companion crops tend to increase the competition with most grass and legume seedings and, hence, the difficulties of obtaining stands.

This is illustrated by many experiments in all parts of the State (Fig. 1). However, the use of fertilizers, lime, and manure increases the yield of hay and pasture, once a good stand has been obtained.

Fig. 1.—The more wheat, the less stand of forage

An alfalfa-clover mixture on the fertility range, Miami County Experiment Farm, April 24, 1935. Left, Plot 10, unfertilized check; right, Plot 9, wheat fertilized with manure and 0-14-6. The alfalfa-clover mixture was sown on these plots in wheat in March, 1934.

It is obvious that no attempt should be made to reduce the fertilizer treatment in a rotation simply to increase the chances of getting good stands of forage in the small grain; rather, the emphasis should be placed upon methods of seeding which will ensure stands when the grain crop is large.

EVALUATING EXPERIMENTS WITH SEEDING METHODS

Evaluating seeding tests is a difficult problem. The simplest and most obvious basis for judgment is the yield obtained the next year after seeding. However, different seeding techniques on the same date, or even in the same general season, can influence yield only through the stand obtained or the vigor of the plants, and very considerable variations in stand may result in small or no variations in yield (16). Soil variations and other experimental errors, on the other hand, often produce differences in yield which appear considerable.

The number of possible variables is so great, and the variables are so greatly affected by season, that it has seemed better to run a large number of tests once or twice each season and for a series of years than to cut down on the number of variables and increase the number of plots in order to give increased accuracy. For example, a sweet clover seeding test continued for 6

years at Wooster included 52 treatments each year, none of them repeated; a test of methods and dates of seeding alfalfa, red clover, and sweet clover at Columbus includes 86 plots, with each treatment only duplicated.

Under these conditions, it seems that the stands obtained may often be a better measure of the surety of a method of seeding than the yields. Initial stands of 100 and 300 plants per square yard will yield about the same amount of hay in the year after seeding; but there would seem to be little doubt that the surer method was the one which gave, significantly, the larger number of plants.

Another difficulty with data on methods of seeding is that many factors are only occasionally critical, so that average data hide, rather than reveal, the possible significance of the data. For example, following oats sown at 4, 9, and 14 pecks per acre, the 4-year average yields of sweet clover hay at Wooster were, respectively, 5100, 5040, and 5100 pounds per acre; yet in dry seasons (and only then) heavy rates of planting oats cut the stand obtained nearly one-third (Table 1). Such exceptional results tell us more about the circumstances under which a seeding practice will be advisable than the averages do.

TABLE 1.—Effect of Rate of Seeding a Companion Crop of Oats on the Stand of Sweet Clover in Dry Years

Columbus—1925		Wooster—1930	
Oats, rate per acre	Sweet clover, plants per square yard	Oats, rate per acre	Sweet clover, plants per square yard
Pecks	*No.*	*Pecks*	*No.*
4	101	4	121
8	76	9	100
16	64	14	96

Even poor stands give some return, and poor stands of those perennial forage crops of which the plants enlarge, like alfalfa, or spread, like blue grass, brome grass, and reed canary grass, may give nearly full crops in later years. The final outcome of the seeding may, therefore, in certain cases, be successful in spite of the seeding method, rather than because of it. For example, an alfalfa-timothy mixture was sown at Columbus on September 15, 1933, much later than is usually desirable or even safe for alfalfa. In 1934 this plot produced 2180 pounds of hay per acre (one cutting) of which 160 pounds were alfalfa. In 1935 the plot yielded 10,110 pounds of hay per acre (three cuttings) of which 7350 pounds were alfalfa.

Furthermore, there are many successful methods of seeding. Although 1934 was, in general, an unfavorable year for seedings, in 1934 profitable stands of alfalfa were obtained at Columbus by 36 distinctly different methods of seeding, and many other stands were also obtained that would have made half to two-thirds of a crop in 1935, and a full crop in 1936.

It does not follow, however, that all 36 successful methods were equally good. In evaluating them as to safety, where yields were essentially equal, stand counts may show what methods are most likely to give satisfactory stands regularly. Stand counts have the additional advantage that one may obtain information of value from them without carrying the experiment through to maturity of a hay crop.

WHY DO SEEDINGS FAIL?

Seedings fail for a wide variety of reasons. It is common to classify these generally, for example: "poor seed", "unfavorable season", "winterkilling", and the like, but these generalities are only slightly helpful. Seedings fail for reasons which are specific and local for each seed sown; and the stand obtained is the summation of these local effects. The more nearly we approximate knowing the reason for the failure of each seed sown, the better.

The following outline gives, somewhat in order of time of failure, the more important causes of failure to obtain stands:

1. The seed may fail to germinate because of:
   a. Dead or weak seed
   b. Hard seed
   c. Unfavorable seeding conditions
2. The seedlings may be killed before establishment by:
   a. Freezing
   b. Too deep coverage
   c. Crusts on the soil
   d. Drying out of the seedbed
3. Seedlings may become established, but die thereafter from:
   a. Lack of inoculation of legumes
   b. Unfavorable soil conditions
   c. Insects or diseases
   d. Drouth
   e. Competition of companion crops
   f. Competition of weeds
   g. Poorly adapted seed
   h. Winterkilling
      (1) Late seeding
      (2) Untimely clipping
      (3) Poorly adapted varieties

FAILURE OF SEEDS TO GERMINATE

DEAD OR WEAK SEED

Good stands cannot be had from seed of low germination. The Ohio Agricultural Seed Law requires the seedsman to state the percentage of germination on the label attached to the container. The labels should always be carefully examined for this and other information. Forage crops seeds can readily be tested for germination at home[5]. Ohio residents may send samples to the Seed Laboratory, Bureau of Plant Industry, State Department of Agriculture, Columbus, Ohio, for a germination and purity test. "Test, don't guess" is as important with forage seeds as with seed corn. Old seed or seed that has been improperly stored is likely to be of low germination, or the sprouts may be weak, or both. The strength of the sprouts, as well as the percentage of germination, should be considered in evaluating seed.

Strong, viable seeds of forage crops will retain their vitality for several years if stored in a dry, cool place where the temperature is uniform, but under average storage conditions, 1 to 3 years is about the limit of safety.

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[5]Directions for making germination tests of forage crop seeds can be obtained from the Department of Agronomy, Ohio Agricultural Experiment Station, Wooster, or the Ohio State University, Columbus.

HARD SEEDS

When legume seeds are tested, a certain proportion of them will usually remain unchanged on the blotters while the others either germinate or mold and decay (Fig. 2).

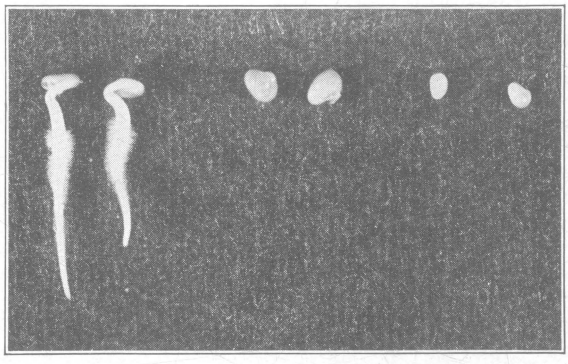

Fig. 2.—Germinated, permeable, and impermeable or "hard" seed

Wooster. Red clover seed removed from germinator at the end of 5 days (X 1.6). Left, seed sprouted; center, seed swelled but not sprouted; right, hard seeds unchanged in the germinator

These unchanged seeds have waterproof seed coats which keep the interior of the seeds as dry as if they were in storage. These "hard" seeds may remain in a moist place under germinating conditions for months or years without swelling or decaying. Finally, when the seed coats decay or are broken by temperature changes, the seed germinates. Hard seeds promote the survival of the species, since seedlings will be produced over a period of years from one seed crop. Red clover and alsike clover seeds, before threshing or hulling, may contain 80 to 95 per cent of hard seeds. These are responsible for many of the volunteer stands of clover on farms where ripened seeds are plowed under with the sod or where manure from clover hay containing ripe seeds is spread. Many times these volunteer stands of clover add much to the success of the clover crop. This is a common experience on the Experiment Station farm.

Shattered sweet clover seeds also continue to produce volunteer plants in a field for several years, because of the hard seeds. These plants may be objectionable when clean alfalfa or clover hay is wanted, but may be of value where a continued stand of sweet clover is wanted for pasture. A field at Columbus which produced sweet clover seed in 1922 still produces so much volunteer sweet clover that it is worthless for forage crop experiments.

The hard seeds of alfalfa, hairy vetch, and crimson clover become permeable and germinate sooner in the soil than do those of other legumes discussed. Many of them germinate in a few weeks and practically all of them, in a year's time. Consequently, hard seeds of alfalfa are of immediate value in obtaining stands.

GETTING HARD SEEDS TO GROW

A considerable proportion (but by no means all) of the hard seeds in a sample will germinate in the late winter if sown while freezing and thawing are still taking place, so that seed which contains a high proportion of hard, impermeable seeds may be sown earlier than permeable seeds. This is frequently done with sweet clover.

Commercially, seed with a high proportion of hard seeds is often "scarified". This consists of blowing the seed at a high rate of speed over coarse sandpaper or passing it between rapidly revolving steel disks. The seed coats are thus scratched sufficiently to admit water and permit germination (Fig. 3). Scarified seed loses vitality rapidly, so that such seed more than 1 year old may be weak and low in germination.

Fig. 3.—Effect of sowing unscarified sweet clover late in the spring

Columbus, April 15, 1932. Left, scarified sweet clover; right, seed in the hull, both sown April 18, 1931, in wheat

WHAT CONDITIONS ARE REQUIRED FOR GERMINATION?

Given seed capable of germination, three things are needed to induce germination: (a) sufficient moisture, (b) favorable temperature, (c) sufficient air. With these things in proper balance for the particular seed, viable seed will germinate.

Insufficient air is seldom a problem with forage seedings, which are usually made shallow. A familiar illustration of the effect of lack of air on germination is that of corn planted deep just before a prolonged warm, wet spell. The saturated soil keeps out the air, causing the seed to die and then rot.

Favorable temperatures for forage seedings are largely regulated by the date of seeding. Most forage seeds will remain dormant for some time after seeding if sown when the weather is too cold for germination.

The dominant problem, therefore, in obtaining satisfactory germination is to provide sufficient moisture over a long enough period for the seeds to establish themselves. The moisture problem is involved in the preparation of the seedbed, the date of seeding, the method of seeding, the depth of coverage, and the use of mulches.

EARLY HAZARDS TO THE SEEDLINGS

FREEZING

Late winter and early spring seedings are exposed to the hazard of freezing. Seed can be sown very early and endure even prolonged sub-zero weather if it has not germinated, but if a warm period intervenes in which the seeds start to grow, followed by low temperatures for a time, the seedlings will be killed.

Both at Wooster and at Columbus, good stands of alfalfa have been obtained by seeding in January, even when prolonged zero weather followed. However, when seeding took place January 1, followed by 2 weeks of warm weather which brought the plant to the seedleaf stage, and then by zero weather, nothing was left alive.

The senior author has found in laboratory studies in which seeds of varying moisture contents have been subjected to various temperatures below freezing that alfalfa, red clover, and sweet clover seeds are not easily damaged by temperatures a few degrees below freezing even though they have taken up considerable water, if they have not sprouted (Fig. 2, center). However, when the young root is breaking through the seed coat, or slightly later, temperatures lower than 26° F. will kill most of them. This is in agreement with the findings of Steinbauer (10).

Important methods of avoiding or reducing freezing injury to spring seedings are: choosing the most favorable date of seeding, split seedings, the use of mulches, getting the seed covered by soil, and, with sweet clover, the use of unscarified seed.

DEEP COVERAGE

Most forage crop seeds are small, and the seedlings cannot force their way to the surface if covered too deep. Critical experiments on depth of seeding are lacking, but there are many experiences of poor, thin stands following too deep seeding with or in front of a drill (Fig. 4). On the other hand, as soon as the weather is warm enough that the surface soil dries quickly, failure to cover the seed is also fatal to good stands (Fig. 20).

The method of seeding and the date of seeding are both concerned with the question of coverage.

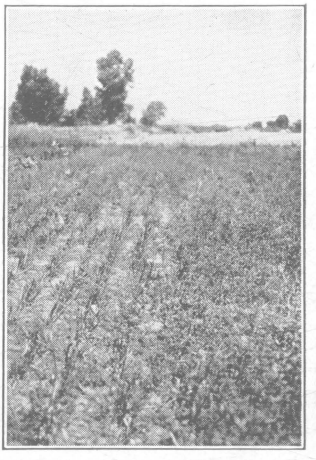

Fig. 4.—Poor stand from too deep seeding

Columbus, August 3, 1922. Left, sweet clover accidentally sown down the grain tubes with the oats, April 1922; right, seed broadcast in front of disks on grain drill

CRUSTS ON THE SOIL

Closely related to coverage is the problem of crusts that form on the soil and prevent the emergence of seedlings. Many soil types tend to form crusts, which are often fatal to the prospective stand. There is no possibility of breaking up a crust over small-seeded forages after it has formed, as is sometimes done over soybean seedings. Experiments (2) have shown that seedlings emerge through a crust better if the soil under them is as firm as the crust.

Germinating seeds exert considerable force; the difficulty is that loose seedbeds cannot resist the downward thrust, so that the seedlings cannot break the crust. If the soil is firmly packed around and below the seedling, the seedling is prevented from curling under the crust, and, so, it may exert greater force to break the crust. Mulches are extremely valuable in preventing the formation of hard crusts. Soils containing an abundance of organic matter do not crust as badly as those which are exhausted by cropping. A common experience is to obtain a perfect stand on a part of the field where a sod has recently been plowed down, although only a mediocre stand is obtained on the remainder of the field depleted of organic matter by cropping.

DRYING OUT OF THE SEEDLINGS

This difficulty arises when a small amount of moisture starts the seed into germination but the soil is dried out before the seedling can establish itself. When seedings are made before April 1 in southern Ohio, or April 15 in northern Ohio the soil seldom dries out before the seedlings can establish themselves. Later seedings are progressively more subject to this hazard, until it becomes a major one in summer seedings. Early seeding, firm soil under the seed, proper coverage, mulches, and sufficient reserve moisture in the soil are the major points to be observed in avoiding loss of stands from drying.

LATER HAZARDS TO SEEDINGS

Many a promising stand in the seedleaf stage has succumbed to unfavorable conditions a little later.

LACK OF INOCULATION

In order to be successful legumes must be provided, either naturally or artificially, with the proper bacteria on the roots. Uninoculated plants often die, or if they survive, are low in protein and do not build up the soil. On soils which have not grown the legume to be sown or one of that inoculation group in the last 5 years, inoculation should be provided, or even more often if the soil is near the lower limit of acidity for the crop to be grown.

The latest directions for the inoculation of legumes may be obtained from the Department of Agronomy, Ohio Agricultural Experiment Station, Wooster, Ohio.

LACK OF LIME IN THE SOIL

Legume seeds will germinate in strongly acid soils, but the seedlings soon begin to show the effect of the lack of lime by a slowing up of growth and a general sickly appearance. Many plants die in a few weeks' time, and many more are killed during the first winter. Winterkilling is less likely to occur on well-limed soils, because the plants have made good growth of both tops and roots before winter. Many a clover and alfalfa failure which is attributed to dry weather, unfavorable season, and the like is really due to insufficient lime.

The response of various legumes to soils of different reactions is illustrated by an experiment at Wooster (Table 2).

Although stand counts have not been made in this experiment, observation shows clearly that the number of plants, as well as their size and vigor, was unfavorably affected at the lower reactions.

All of our common legumes except sweet clover make their best growth at pH 6.8, or just below the neutral point. On soils which have a limy layer at 20 to 30 inches, as have a large proportion of the soils in western Ohio, good stands may be obtained even though the topsoil is somewhat acid.

TABLE 2.—Relative Yields of Legumes at Different Soil Reactions (7). Seven-year Average, Wooster. Experiment 31

Fertilizer treatment: 400 pounds of 20 per cent superphosphate and 50 pounds of muriate of potash per acre on the small grains in which the legumes were seeded. Lime was applied in varying amounts according to the reaction desired.

Soil reaction	Relative average yields; highest yield equals 100					
	Alfalfa	Sweet clover	Medium red clover	Mammoth red clover	Alsike clover	Soybeans
pH						
4.6	3	0	16	17	14	67
5.0	9	2	30	30	28	79
5.6	41	44	58	67	74	78
6.8	100	90	100	100	100	100
7.7	99	100	98	91	94	95

Samples of soil are tested, and recommendations as to the amount of lime needed for the growth of various legumes on these soils are made free by the Department of Agronomy, the Ohio State University, Columbus, Ohio.

LACK OF NECESSARY CHEMICAL NUTRIENTS IN THE SOIL

Legume seeds will germinate well in a poor soil, but by weak growth and loss of vigor the seedlings soon show the effect of starvation, which makes them susceptible to disease and winter damage.

Commercial fertilizer.—Probably because of its effect in stimulating root growth (9), nothing helps more in establishing a legume seeding than an abundance of phosphorus in the soil. Applications of superphosphate or, where potash is also likely to be deficient, of 0-14-6 are often worth more than their cost in helping to ensure a good stand of legumes (20) (Fig. 5). Although no specific experiments on that method of application have been conducted, farm observations suggest that drilling superphosphate or 0-14-6 with the seed is an effective method of application.

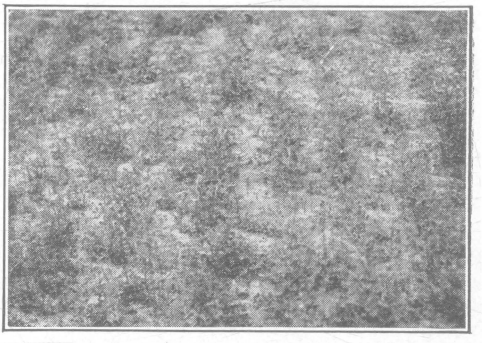

Fig. 5.—Fertilizer helps establish seedlings.

Columbus, September 19, 1933. Rows in alfalfa seedlings due to 500 pounds per acre of 0-14-6 drilled with a grain drill before seeding. Sown July 28, 1933. The actual rows of plants are diagonal to the direction of drilling the fertilizer. Some of them can still be distinguished in the lower left center of the picture.

Manure.—On many soils, and especially on poor soils, the use of manure before seeding or as a top-dressing after seeding does much to ensure a satis-

factory, vigorous stand (Fig. 29). This favorable effect of the manure is in part due to the nutrients and organic matter it provides and in part to its effect as a mulch. For the latter use, other materials, such as straws and cornstalks, will also serve.

INSECTS AND DISEASES AS SEEDLING HAZARDS

Insects and diseases frequently cause more or less injury to the young forage seedlings, sometimes causing near-total losses. Examples are the clover leaf weevil, pea aphids, grasshoppers, and leafhoppers, among insects, and anthracnose and *Sclerotinia trifoliorum* among diseases.

DROUTH

Drouth is a common and serious enemy of young legume stands. However, when crops are sown without the competition of a companion or so-called "nurse" crop, it is usually only on very drouthy soils, particularly sands, that difficulty from drouth is encountered in spring seedings. Even in years of severe drouth, like 1930, 1934, and 1936, alfalfa and clover sown alone in the spring survived. They will usually survive in summer seedings also, if they actually become established.

COMPETITION OF COMPANION OR "NURSE" CROPS

The difficulties usually attributed to drouth are largely due to the crops in which the forages are sown. These crops have been miscalled "nurse" crops for so long that many think they really have a protective effect on the forage seedings. The cereal crops in which forages are usually sown are never directly beneficial to them, except when the forages are sown on sloping fields, where the more rapidly growing cereals may provide some protection against erosion before the small seedlings are established. The cereals make obtaining a stand less certain; they result in smaller and weaker forage crop plants which do not endure the winter as well as those which have not had such competition; and they accentuate the bad effects of either dry or wet weather on the young stands. In a dry season their roots outgrow those of the forage seedlings and may so rob them of moisture as to cause their deaths, especially the clovers' (Fig. 6). In a wet season the rank growth of the companion crop may shade the young seedlings so much that it will weaken or kill them. Lodging of the companion crop, common in wet seasons, is practically always detrimental to the forage seeding.

Companion crops are used for three basic reasons: first, they produce a return from the land in the seeding year; second, if they are not used, a more harmful companion crop of weeds may replace them; third, on sloping land they help to control erosion while the small-seeded forages are becoming established. Nevertheless, the companion crop is always a competitor of, and usually a detriment to, the forage seeding.

In general, the less the growth of the small-grain companion crop under a given soil situation, the better the seeding in it. It is a common observation that stands of grass and legumes are frequently better in stands of wheat that have been thinned by winterkilling than in normal thick stands. Where wheat follows corn better forage crop stands are usually obtained in the spots where no wheat was sown in the fall because of the presence of corn shocks. There have been repeated instances in the fertilizer experiments on the outlying

experimental farms in the State where thick stands have been obtained on the unfertilized plots and at the same time thin stands have been obtained on the fertilized plots which produced a rank growth of wheat (Fig. 1).

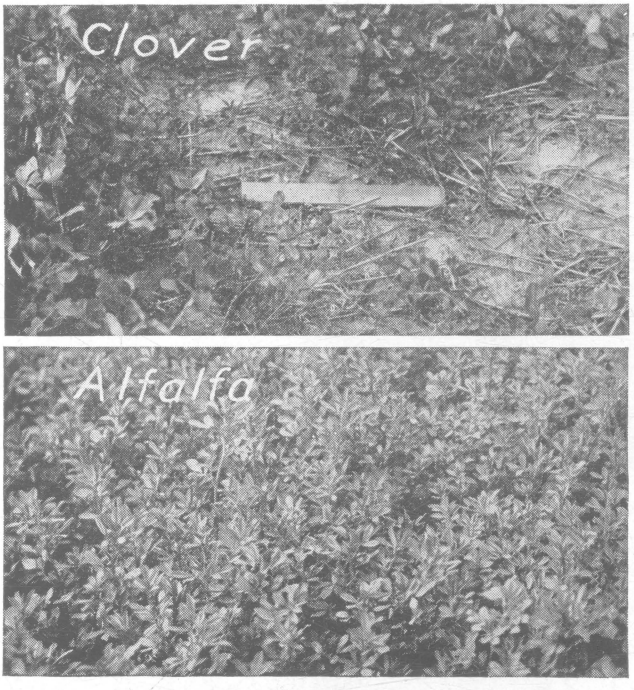

Fig. 6.—Alfalfa establishes itself in dry seasons.

Columbus, May 15, 1931. Alfalfa and red clover sown in oats on April 5 of the drouth year, 1930

COMPETITION OF WEEDS

A reason usually given for using a companion crop is that the companion crop "keeps down weeds". Certainly, experience has shown that when a companion crop is not used, one may have a "companion crop" of weeds which do the forage as much or more harm than the cereals and are worth nothing. Weeds may also appear after the companion crop has been harvested, so that means for their control are important. Clearly, the only practical control for weeds in the new forage seedings is mowing. This is reasonably effective with some weeds. Others, such as foxtail and crabgrass, are practically unaffected by mowing.

POORLY ADAPTED SEED

Even though a stand is obtained, if varieties are sown which are not adapted to the locality, the crop harvested is not likely to be satisfactory, and the stand may be destroyed before harvest. Examples are alfalfa seed from Arizona and adjacent areas, which may winterkill; certain foreign alfalfas and red clovers which are non-hardy, or disease-susceptible, or both; and northern red clover in the southern part of the State, which may be seriously injured or even killed by disease.

WINTERKILLING

Winterkilling is a not infrequent hazard of seedings. It may follow late seeding, poor development on account of drouth or lack of nutrients or lime, untimely clipping, or poorly adapted seed.

SEEDING TECHNIQUES AND MANAGEMENT

Such are the more important causes of failures to obtain seedings. The practical seeding operations necessary to avoid these difficulties are considered in the present section.

LESSENING OR AVOIDING THE COMPETITION OF COMPANION CROPS

The competition of small-grain companion crops with legume-grass seedlings may be more or less controlled by (a) choosing the right companion crop, (b) selecting the variety of the companion crop with care, (c) clipping the early growth, (d) grazing off the early growth, (e) harvesting for hay, (f) reducing the rate of seeding of the companion crop, and (g) sowing without a companion crop.

WHICH OF THE SMALL GRAINS IS THE BEST COMPANION CROP?

Under some conditions there is little difference. For instance, in the rotation experiment at Wooster, the 17-year average yields of clover following wheat, oats, and barley, respectively, were 3810, 3810, and 3740 pounds per acre. However, especially in the western half of the State, there is no doubt but that spring grains are usually safer companion crops than winter grains (Fig. 7), although good stands may be obtained in wheat.

Fig. 7.—Oats are usually preferable to wheat as a companion crop.

Southwestern Experiment Farm, September 6, 1935. Left, 4-4-2-4 mixture sown in oats, spring of 1935; right, same, sown in wheat. Same field, about a rod apart. See Mixture No. 3 under "The Value of Seeding Mixtures".

Seedings made in wheat must compete from the very start with a well-established crop; whereas those sown with oats or barley can grow along with the grain on fairly even terms until the grain crop starts to joint (Fig. 8). This difference applies especially to alfalfa, which is sensitive to shade but stands drouth well. Red clover, which endures shade well but is more sensitive to drouth, may do as well in wheat as in oats, since wheat is harvested earlier. Wheat also often permits earlier seeding than oats.

Fig. 8.—Oats versus wheat as a companion crop for alfalfa

Columbus, May 28, 1931. Left, alfalfa sown in winter wheat on April 1; right, Fulghum oats and alfalfa sown April 9. The wheat, 30 inches high, was cut off short in order to photograph the alfalfa plants. Same scale in both

Although exceptions exist, the usual order of value in Ohio is barley, early oats, late oats, and wheat. We have few data on rye and winter barley as companion crops, but their habit of making a rank growth early in the spring may make them unsatisfactory. Kinney, et al. (5) say:

"For Kentucky, wheat is probably a better nurse crop than rye, unless the rye is pastured. Winter barley, if not too thick or if pastured, is very satisfactory. Unpastured barley on very fertile soil often makes such a rank growth as to smother the crops sown with it".

OTHER COMPANION CROPS

Other crops may occasionally be considered as companion crops. Canning peas make an excellent companion crop, since they are sown early and removed early. Their use is, of course, limited to the few areas in which they are a commercial crop.

Winter wheat, spring sown.—Winter wheat sown in the spring at the time of seeding the forage crop has been suggested (20) as a companion crop. Sown in this way, winter wheat does not form heads, but makes a grasslike growth which usually dies in the summer from the attacks of leaf rust. The wheat keeps down weed growth somewhat until the forages are established, does not have to be harvested, and competes with the forages less than cereals left for grain. Excellent stands of alfalfa and other forage crops have been obtained by sowing this way. However, on rich soils the growth of even spring-sown wheat has killed alfalfa sown with it (Fig. 9). It is obvious that spring-sown winter wheat not only keeps down weeds, but also "keeps down" the forages sown with it in the same way. When sowing alone has been compared with sowing in spring-sown winter wheat on soils of medium fertility, the differences have not been great (Table 3), so that it is not clear that the additional expense of the wheat is justified, except to reduce erosion on rolling land, or perhaps, as a companion crop for sweet clover, which cannot be clipped satisfactorily (15).

Soybeans.—A great many inquiries have been received regarding the sowing of clover, alfalfa, sweet clover, and mixtures in soybeans. Tests at the Experiment Station at Wooster and on several of the outlying experiment farms show that soybeans are not dependable as a companion crop (11). Sow-

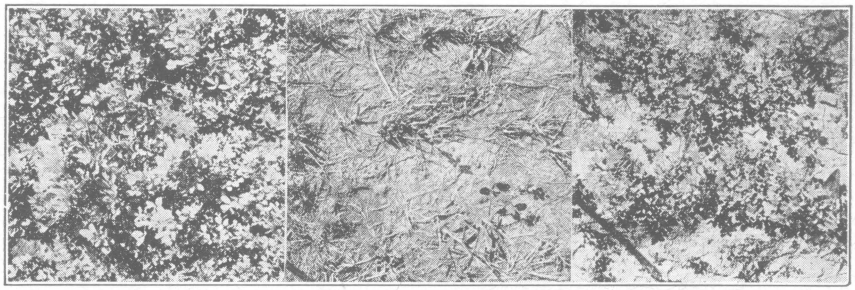

Fig. 9.—Spring-sown winter wheat may kill alfalfa sown with it.

Columbus, August 14, 1933. Plots of alfalfa sown April 10, 1933. Growth cut and removed July 24, 1933. Left, following timothy sod plowed in March and spring-sown winter wheat used as a companion crop. Center, following red clover sod plowed under and spring-sown winter wheat used as a companion crop. Right, same as center, except that alfalfa was sown alone. Following red clover (center) the wheat made a growth of 12 to 14 inches and smothered the alfalfa seedlings.

TABLE 3.—Comparisons of Methods of Seeding on Spring-prepared Land

Year sown	Yield of hay per acre		
	Sown alone Lb.	Sown in spring-sown winter wheat Lb.	Sown in oats Lb.
Columbus, red clover, June of year after seeding			
1932	4710	5090	4060
1933	3150	3150	2560
1934	4990	5630	4510
Average	4280	4620	3710
Columbus, alfalfa, June of year after seeding			
1932	2910	3220	2460
1933	3980	4170	3340
1934	5860	5410	4800
1935	4190	4290	4180
Average	4240	4280	3700
Columbus, sweet clover, June of year after seeding			
1932	2190*	1650*	1950*
1933	4870	3980	4300
1934	6340	6070	5700
1935	3860	5290	5360
Average	4320	4250	4330
Wooster, alfalfa, three cuttings the year after seeding			
1933	9040	8960	7640
1934	8970	8430	7380
Average	9010	8690	7510

*In November of seeding year.

ing after soybeans is probably safer. When the soybeans were harvested for grain, no stands of the legumes or grasses sown in soybeans were ever obtained on any soil type. When the soybeans were harvested for hay, a number of satisfactory legume-grass seedings were obtained on Wooster soil, which has excellent water-furnishing properties, but the method is too uncertain to be recommended. It was always noticeable that the best stands of legumes were found where, because of poor growth or poor stands, there was a small or thin growth of soybeans. The best results were obtained with Manchu soybeans drilled about May 20 to 25 at the rate of 4 to 6 pecks per acre; the legume or grass seeding was made at that time, and the soybeans were harvested for hay in August. This method prevents controlling of weeds in the soybeans by any method of harrowing or cultivation. Alfalfa made better stands than the other legumes in these tests.

Corn.—It would simplify rotation problems in Ohio greatly if it were possible to count on obtaining a stand of forages regularly by sowing in corn at the last cultivation, but in practice, the method is too uncertain to recommend except as an emergency measure. In long-time tests both at Wooster and at Columbus, satisfactory stands have been obtained in less than half the seasons. Hairy vetch has been the most uniformly successful forage to sow in corn at the last cultivation. Alfalfa has been next, and much the most successful of the standard hay crops when sown in corn. The true clovers, red and alsike, have been next most successful. Sweet clover has been so uncertain that it would not be worth trying, were it not that sweet clover seed is usually cheap. On soils which furnish water to seeds readily, sweet clover may be worth sowing in corn for soil improvement even though the returns from such seedings are far less than those from spring seedings.

Even when generally satisfactory stands are obtained in corn, the corn hills leave bare places which later offer opportunity for weed growth, and the uneven surface and the corn stubs make harvesting the first crop of hay very unsatisfactory and the hay of poor quality.

When seeding in corn is done at the last cultivation, the question is often raised whether it is better to broadcast the seed and then make the last cultivation, or to make the last cultivation and broadcast the seed on the loose soil. The two methods have been compared at Columbus for 9 years with a large number of forages and mixtures. The differences between the two methods have not usually been large, but there has been a distinct general tendency for the large-seeded forages (vetch, rye, soybeans, and cowpeas) to make better stands when cultivated in, and for the small-seeded forages (seeds smaller than those of the crops just mentioned) to make better stands when sown on loose soil after the last cultivation. In either case, plants are seldom established on undisturbed soil, so that as much of the surface as is feasible should be loosened with the cultivator.

CHOICE OF VARIETIES OF COMPANION CROPS

The more favorable varieties of small grains for companion crops will (a) be stiff strawed and hence lodge resisting, (b) make a minimum of leaf growth, and (c) be early maturing.

CLIPPING THE EARLY GROWTH

Occasionally, a combination of favorable weather conditions and fertility causes a rank growth of wheat early in the spring, followed by excessive straw growth and lodging which kill out the legume or grass seedings. If the April

growth of wheat has been rank and covers the ground between the drill rows, it may be clipped with a mower. This clipping should be done in the last 2 weeks of April or in very early May; the exact time should be determined by watching the embryo heads in the developing wheat plants. This can be done by splitting the stalks with a knife and noting the height of the head which is readily visible in the heart of each developing stem. The wheat should be clipped before there is any likelihood of cutting off these heads. If this is done, the wheat will recover and make a grain crop; usually the yield will be reduced, but if the unclipped wheat with which it is compared lodges badly, the yield may even be increased.

The effect of clipping is to reduce greatly the competition of the grain crop with the developing forage plants for a period of 10 days to 2 weeks. Apparently, this period in the life of the forage seedlings is a vital one, since stands have been saved in this way when cutting the companion crop for hay did not save them. Clipped wheat seldom lodges, and this removes another serious hazard to the seeding, but clipping has saved stands even when the unclipped wheat did not lodge.

At Wooster, on May 1, 1935, a strip was clipped at a height of 4 inches through a field of rank-growing Fulhio wheat (Fig. 10) which was 12 to 14 inches tall at that time. The yield of the clipped wheat was 37 bushels of grain and 3500 pounds of straw, of that not clipped, 41 bushels of grain and 5200 pounds of straw. Although this wheat lodged (Fig. 10, B), it did so late enough to permit the grain to fill fairly well. Similar results from clipping wheat were obtained at Columbus and at the Hamilton County Experiment Farm in 1935.

The early clipping of oats and barley companion crops is seldom necessary, since, if properly seeded, the grain crop and the legume or grass crops have an even start and strong competition does not set in until the grain crop has jointed.

GRAZING OFF THE EARLY GROWTH

When wheat grows rank in the early spring, it may be grazed off with cattle or sheep. In experiments at Wooster[6] extra good stands of alfalfa, clover, timothy, and mixtures have been obtained by grazing the wheat crop. Grazing may begin as soon as the wheat is large enough to furnish a good "bite", generally about the middle of April, and the field may be grazed until about May 1, if a grain crop is to be harvested, or may be used entirely for pasture, in which event it will last until well into June.

Grazing may be either light or heavy. Close grazing with dairy cattle has been favorable to obtaining good stands of the legumes and grasses. The tramping of the livestock, which firmed the soil, appeared to be beneficial rather than harmful.

The results of grazing experiments with sheep at Wooster are reported in Table 4. No hay yields were obtained in 1935 because the lease on the land had expired, but the growth of legumes and grass in the fall of 1934 indicated that the results would have been similar to those in 1934 (Fig. 11).

[6]The Departments of Agronomy, Animal Industry, and Dairy Industry cooperating.

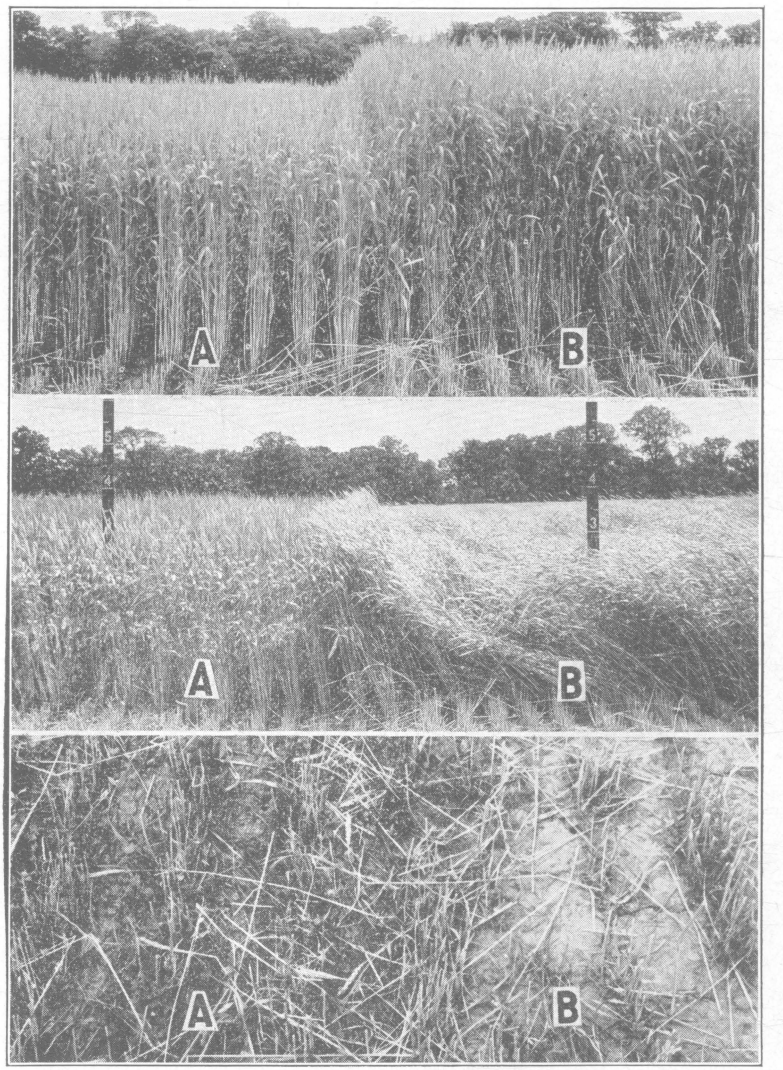

Fig. 10.—Clipping rank wheat to control lodging and save the stand of alfalfa, clover, and timothy

Wooster, 1935. A—Wheat clipped 4 inches high on May 1. B—Wheat not clipped. Top—Appearance June 1. Middle—Appearance June 17. Bottom—Appearance June 12, wheat removed for photographing. A—Good stand of legumes and timothy. B—No stand of legumes and timothy

TABLE 4.—Effect of Grazing Wheat with Sheep on Yields of Wheat and Hay. Wooster, 1933-1934

Five pounds of timothy sown in the wheat in the fall and 8 pounds of red clover, in the spring

	Wheat not grazed	Wheat grazed 10 days	Wheat grazed 22 days
Yield of wheat per acre in 1933, bu	31.8	25.0	13.5
Yield of hay per acre in 1934, lb	1350	2760	2610
Yield of wheat per acre in 1934, bu	19.1	21.1	16.1

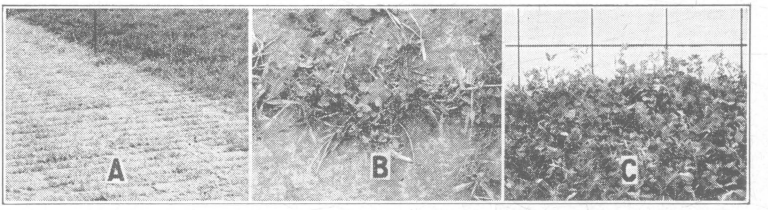

Fig. 11.—Grazing off wheat with sheep

Wooster, 1934. A—May 3, wheat grazed closely by sheep. B—June 20, legumes and timothy in closely grazed wheat row. C—The legume-timothy mixture, September 17. Height, 6 to 12 inches. (Sheep were removed June 27).

Grazing off oats has resulted in obtaining a good stand of legumes or grass. It is best to use them entirely for pasture rather than to attempt to harvest a grain crop after grazing.

HARVESTING THE GRAIN CROPS FOR HAY

If the grain crops start to lodge, or if the season is dry, the forage seedings may sometimes be saved by cutting the grain for hay. Where the death of the seeding is due to too much shade (Fig. 12) it will often be too late to

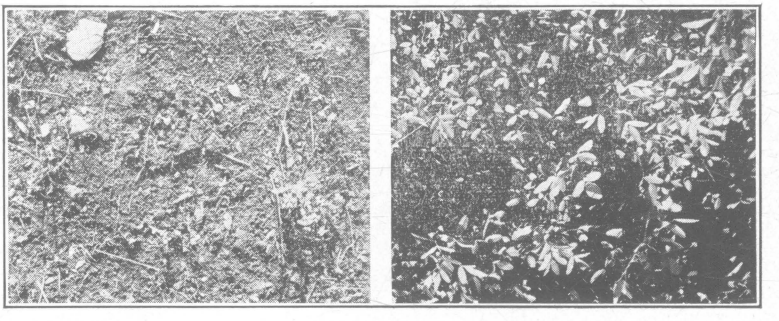

Fig. 12.—Alfalfa succumbs to shade.

Columbus, October 21, 1931. Left, alfalfa (weeds removed from area before photographing); right, sweet clover. Both were sown in wheat on fertile soil April 15, 1931. Areas less than a rod apart. Alfalfa germinated well. Wheat did not lodge, but made a dense growth.

save the forage by the time the grain is cut for hay in the milk or soft dough stage. In the Columbus experiments, cutting for hay has saved the stand in a dry June (Fig. 13), rather than in wet ones when heavy growth or lodging was the problem. In 1936 cutting wheat for hay resulted in an average stand of 220 alfalfa and 54 red clover plants per square yard in wheat top-dressed with nitrate of soda; whereas the stands in similar wheat left for grain were, respectively, 62 and no plants per square yard. In 1931 and 1935, two very favorable years for the growth of wheat, cutting the wheat for hay was of no value in saving the stand; whereas clipping the wheat in April saved the stand.

Sweet clover, however, is injured by the low cutting involved in cutting the grain for hay, and it is usually not desirable to cut for hay a companion crop in which sweet clover is sown unless the sweet clover will be killed otherwise.

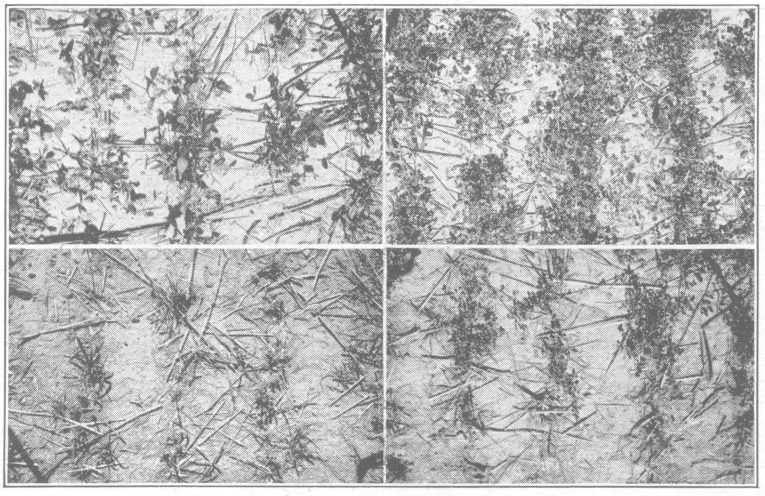

Fig. 13.—Cutting wheat for hay

Columbus, September 9, 1936. Wheat top-dressed with 300 pounds of nitrate of soda per acre April 7; this resulted in a heavy growth but no lodging. Stubble clipped August 31, 1936. Top, wheat cut for hay June 11, 1936; bottom, wheat left for grain. Same drill rows for each crop. Left, red clover drilled in wheat April 1, 1936; right, alfalfa broadcast April 20. Where the wheat was not top-dressed with nitrate, cutting for hay had very little effect on the stand of alfalfa. Average stands above: wheat cut for hay, red clover, 71, alfalfa, 192 plants per square yard; wheat left for grain, red clover, 0, alfalfa, 48.

REDUCING THE RATE OF SEEDING OF THE COMPANION CROP

In accordance with the general rule of "the less companion crop, the better the stand of forage", we find that a low rate of seeding grain favors the stand of legumes in so far as it actually makes for thinner grain stands. Wheat stools out so much that unless the thin stand is winterkilled, the rate of seeding in the fall has little effect on the yield of straw (Table 5). For this reason, and since winterkilling is rather more likely to occur in thin stands, it is not recommended to sow wheat thin with a view to obtaining better forage stands.

TABLE 5.—Rate of Seeding Wheat, Wooster, 28-year Average

Rate of seeding	Yield per acre	
	Grain	Straw
Pecks	*Lb.*	*Lb.*
3	27.4	2890
4	29.3	2830
6	31.7	2980
8	32.9	3070
10	32.7	2990

A thin rate of seeding oats may result in a better stand of forage in dry seasons (Table 1); in most seasons there is no significant difference in the stands obtained at the different rates of seeding (Table 6) unless the oats lodge.

TABLE 6.—The Rate and Date of Seeding Oats as a Companion Crop for Alfalfa, Columbus

Average of four replications in 1935 and three in 1936

Rate of seeding Franklin oats	Alfalfa plants per square yard								
	Early seeding			Medium seeding			Late seeding		
	Apr. 1, 1935	Apr. 21, 1936	Av.	Apr. 18, 1935	May 6, 1936	Av.	May 9, 1935	May 15, 1936	Av.
Pecks	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
4	103	99	101	83	65	74	92	133	112
8	87	130	108	78	98	88	89	118	104
12	80	104	92	71	104	88	82	120	101
16	70	74	72	70	105	88	68	87	78

A low rate of seeding for oats does not reduce the yield of oats as much as many imagine. Oats have been sown at various rates in rate-of-seeding tests at Wooster and Columbus. Table 7 gives the average yield of grain and straw in 40 separate tests covering a period of 27 years at Wooster and 7 years at Columbus.

TABLE 7.—Rate of Seeding Oats

Rate of seeding	Yield per acre			
	Wooster, 27-year average			Columbus, 7-year average
	Grain	Straw	Total weight	Grain
Pecks	*Bu.*	*Lb.*	*Lb.*	*Bu.*
4	49.0	2770	4348	49.2
6	54.9	2760	4517	55.6
8	57.1	2650	4477	56.8
10	58.9	2600	4485	56.1
12	58.8	2590	4472	55.7

At Wooster 6 pecks of oats gave an average yield of 54.9 bushels, or but 4 bushels less than the largest yield, 58.9 bushels, for 10 pecks. The straw yields, however, are largest for the thinnest rate and decrease slightly as the rate of seeding increases. The total weight of the crop is largest for the 6-peck rate. Evidently, such advantage as exists for a thin rate of seeding

oats in obtaining good stands of the legumes or grasses is not measured by the yield of straw or the total weight of the crop. The explanation is found in the type of growth made by the companion crop; thin rates of seeding produce large, coarse, stiff straws; whereas thick rates produce a dense growth which competes more with the forage in the early stage and smaller, finer, and weaker straws which stand closer together, producing more shade and likelihood of lodging (13). (See Fig. 14). Since the season cannot be predicted, 6 pecks of oats is recommended as a standard rate when oats are used as a companion crop.

Fig. 14.—Thick seeding tends to make oats lodge.

Columbus, July 5, 1935. Fulghum oats sown April 1. Left, sown at 12 pecks per acre; center, sown at 8 pecks; right, sown at 4 pecks

SOWING ALONE

To avoid entirely the competition of companion crops, forages may be sown alone. Summer seedings should always be sown alone. The custom of sowing in small grain is almost universal because of its economic advantage if stands are actually obtained. For this reason, and because of the use of the term "nurse crop" to describe these crops, many persons have the idea that forages cannot be satisfactorily sown alone in the spring. This idea is entirely erroneous. Experiments with sowing alone in the spring have been conducted both at Columbus and Wooster for some years, and sowing alone has given excellent stands. In favorable seasons, a small yield of hay has been obtained in the seeding year (Fig. 15). The yields of hay in the next year have not been materially different from those obtained from seedings in a companion crop, when the latter gave satisfactory stands (Table 3).

CONTROLLING WEEDS BY CLIPPING

In controlling weeds by clipping, two points are of importance: the size of the weeds when cut, and the height of clipping. Weeds should be allowed to make considerable growth before clipping, as much as is consistent with saving the stand of forage. The reasons for this are: first, to permit the weeds to make growth enough that when they are cut they will be killed; second, to allow the forage to make top and root growth. A tall, dense growth of weeds is more likely to be killed by clipping than a young, scattered, open

Fig. 15.—Alfalfa may be successfully sown alone in the spring.

Columbus, September 20, 1933. Alfalfa sown alone on fall-plowed land, April 4, 1933. Two cuttings of over a half ton each had been removed.

one, since in the former the buds on the weed stubble will have been killed by shading. Clearly, the lower the weeds are cut, the more of them will be killed. On the other hand, red clover and alfalfa recover from crown buds at ground level, whatever the height of cutting (Fig. 16). Consequently, high clipping merely favors the weeds instead of these forages although many directions for clipping new seedings wrongly recommend setting the mower bar high. The recommendation to cut high applies only to sweet clover, which is so seriously injured by clipping (Fig. 17) that it should not be clipped unless the stand will certainly be killed if the weeds are not clipped. Sweet clover recovers after clipping from buds along the stem and, like the annual weeds we have discussed, it will be seriously injured by low cutting.

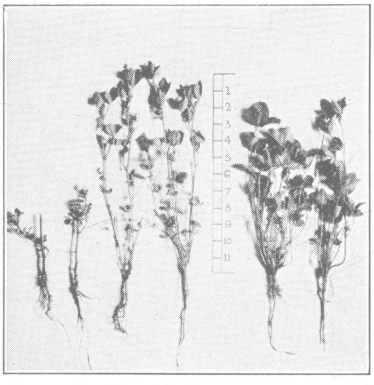

Fig. 16.—Differences in recovery after clipping

Columbus, August 4, 1928. Left to right, sweet clover, alfalfa, red clover, sown April 7, 1928, in Fulghum oats. Oats and legumes cut with mowing machine July 17, 1928

EFFECT OF CLIPPING ON ROOT RESERVES AND ROOT SYSTEMS

Clipping of new seedings has a bearing on another cause of failure of stands, the failure to form sufficient root reserves and root systems to go through the winter. Long-time experiments on the clipping of legume seedings made in oats have been carried on at Columbus and at the Northwestern Experiment Farm at Holgate (7, 14, 15, 17, 20).

Spring-sown alfalfa has been least affected, either favorably or unfavorably, by one cutting or clipping in the summer or fall of the seeding year, but it has been injured by very late clipping (Fig. 18). Red clover was definitely

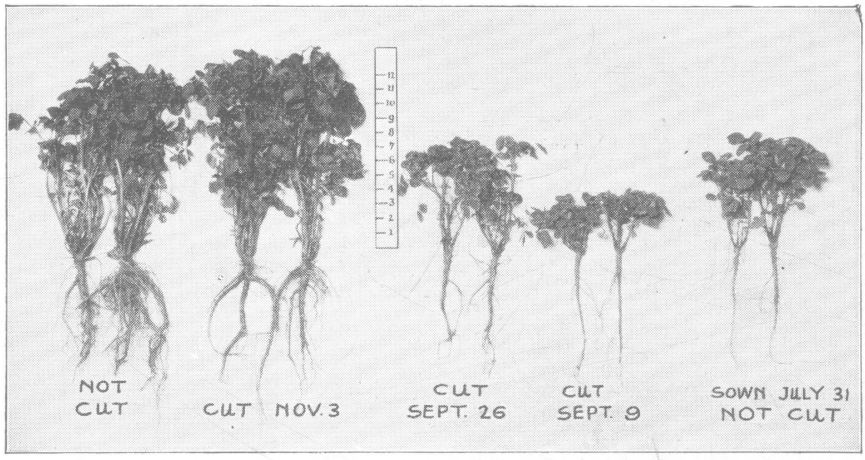

Fig. 17.—September clipping of sweet clover weakens the next year's growth.

Columbus, May 2, 1927. Representative plants from plots of sweet clover sown in oats in the spring and clipped in 1926 on the dates indicated

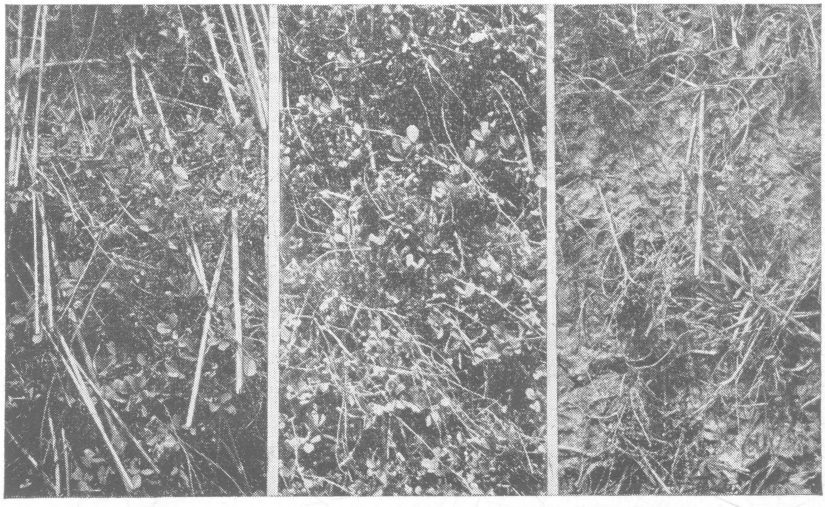

Fig. 18.—Clipping alfalfa late may kill it.

Columbus, April 20, 1928. Alfalfa sown in oats in the spring and the stubble clipped on various dates in 1927. Left, not clipped in 1927; center, clipped August 1; right, clipped November 1

injured by clipping after September 1 (Fig. 19), but the yield the following year is usually somewhat greater following late August clipping than when it is not cut at all. There is a general opinion that allowing red clover to produce seed the first year kills it. This is not true, as was evidenced several times in the Columbus experiments. In 1928, for example, there was an

unusual set of seed in red clover sown that year, amounting to about 2 bushels per acre. Nevertheless, the same stand which produced this seed yield produced a very heavy hay crop in 1929. It seems likely that the fact that if a seed crop is harvested from first-year clover, it is likely to be removed late, so that the stand is winterkilled from lack of winter protection, is at least in part responsible for the experience of poor hay yields following first-year seed crops.

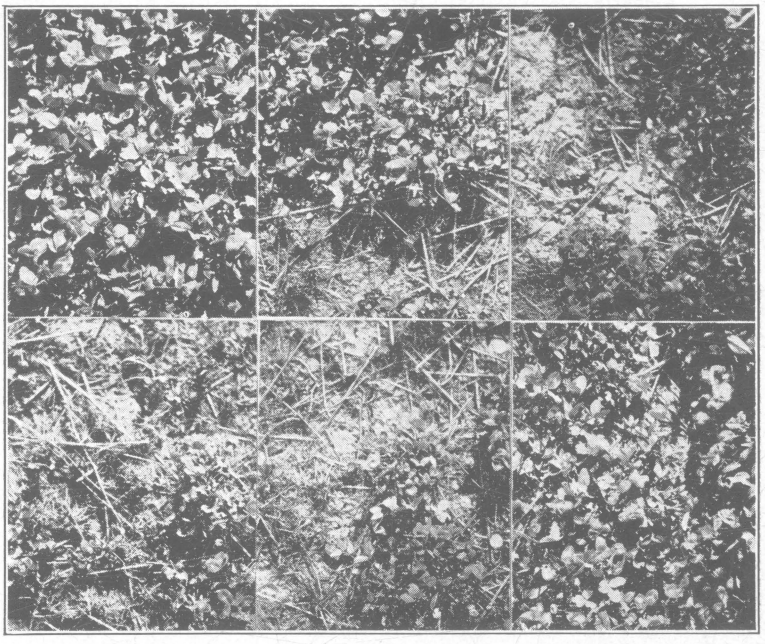

Fig. 19.—Effect of clipping red clover in the seeding year

Columbus, May 1, 1930. Red clover sown in oats, 1929; oats harvested for grain. Clover in oats stubble cut and removed as follows: left to right, top row, cut September 1, September 15, October 1; bottom row, cut October 15, November 1, and not cut after oats harvest. Yields of hay in June were, respectively, 2590, 1380, 710, 850, 790, and 1770 pounds per acre. Seven-year average June yields for the same dates of clipping were, respectively, 3490, 3050, 2870, 3030, 2570, and 3500 pounds per acre.

Sweet clover is most injured by clipping September 1 to 15. Before this period, the earlier, and after this period, the later, it is clipped, cut for hay, or pastured, the better. This is true because sweet clover plants make no further top growth when cut after September 15, and removing the tops prevents further root storage. As a 9-year average at Columbus, sweet clover cut for hay September 15 to 30 has yielded less than half as much nitrogen and organic matter in roots and tops to plow under the following spring as that which was not cut in the seeding year (Fig. 17).

As a general rule, it is recommended to clip spring-sown alfalfa, red clover, or alsike during August of the seeding year; whereas if first-year sweet clover

is to be cut for hay it should be cut as late as practical. The clippings may and should be removed if they are valuable for hay or are heavy enough to injure the stand.

It is not usually necessary or desirable to clip seedings in small-grain stubble more than once, though it has been done experimentally at Columbus a few times without injury. Spring seedings without a companion crop are best cut or clipped twice during the seeding year. The first clipping should be delayed as long as possible, and may usually be left until July. One more clipping late in August will usually control weeds satisfactorily and permit the storage of reserve materials in the roots after the last clipping. However, even at Wooster, alfalfa sown alone in the spring has been clipped three times without apparent injury.

Summer seedings should not be clipped at all the first year (if it can possibly be avoided), since they have only a short time before winter in which to develop a strong root system. Since the growth of roots is dependent upon the growth of tops, to remove the latter seriously reduces the former. If a good job of weed control has been done previous to summer seeding, there will seldom be any weeds to contend with in the fall. However, when weeds, such as red-root pigweed[7] were very serious, July-sown alfalfa was experimentally clipped at Columbus on September 20 without apparent injury.

DATE OF SEEDING

The date of seeding depends on the nature of the plant and affects temperature relations, moisture relations, and the development of the seedlings. There is no month in which some forage seeds may not be sown.

SPRING SEEDINGS (LATE FEBRUARY TO MAY)

Early spring seedings are subject to greater or less freezing hazard. On the other hand, as one sows later and later in the spring, the moisture situation becomes less and less favorable, because evaporation becomes more and more rapid as the season advances. Until about April 1 in southern Ohio, and April

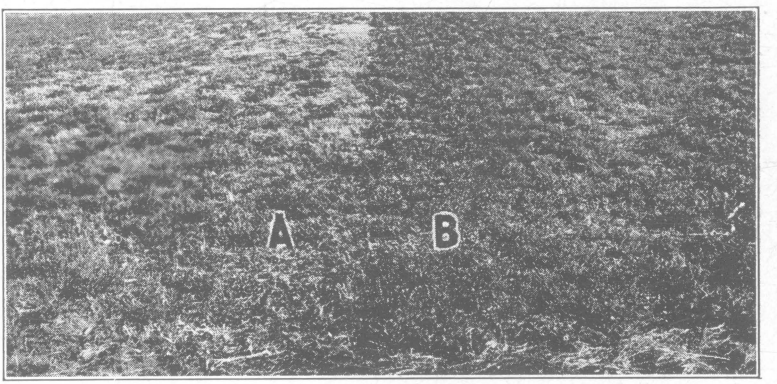

Fig. 20.—Alfalfa seed must be covered.

Wooster, November 9, 1935. A—Alfalfa broadcast on wheat April 25, 1934. Poor coverage. B—Alfalfa drilled on wheat April 25, 1934

[7] *Amaranthus retroflexus* L.

15 in northern, the surface of the soil does not dry out so rapidly but that seeds sown on the surface can usually germinate and establish themselves, even without soil cover; whereas after those approximate dates some coverage is essential to the successful establishment of seedlings (Fig. 20) unless the season is unusually wet. Seeds sown early are usually more or less covered by freezing and thawing and by rain washing the seeds and soil into the wheat drill rows and covering them.

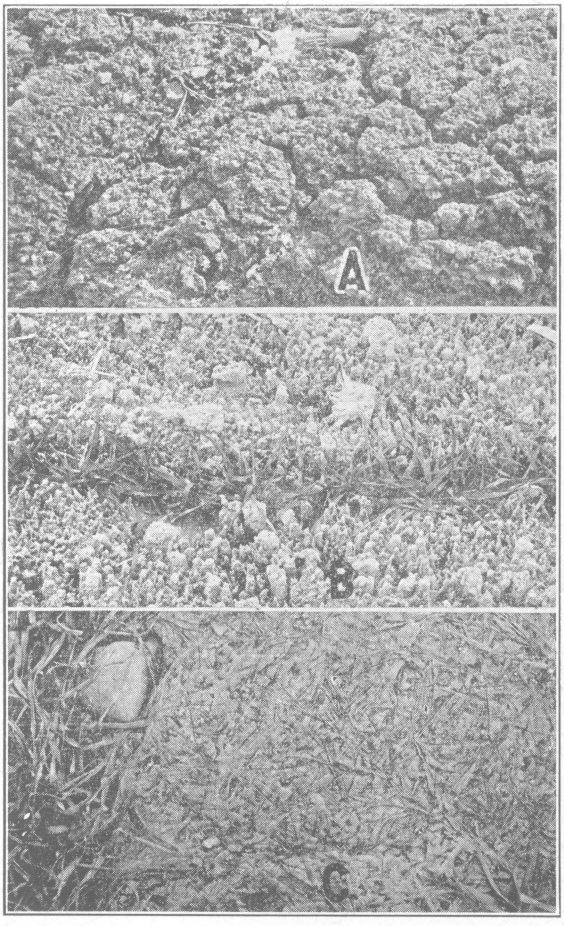

Fig. 21.—Types of soil honeycombing by frost, Wooster

A—On highly organic soil (spring); B—On silt loam soil, November 12, before puddling; C—On silt loam soil, March 22, after one or two frosts had puddled the soil. This (C) is a common type of honeycombing in the spring, and few broadcast forage seeds actually fall into cracks.

The supposition that it is an advantage to sow seeds on honeycombed soil because the seeds are covered by falling into the cracks made by the frost, is not supported by observation. In fact, the type of honeycombing is frequently such that only a small proportion of the seeds fall into these cracks (Fig. 21). Numerous tests have shown that it is not necessary to sow the seed on honeycombed soil; it is just necessary that it be done during the period when freezing and thawing usually take place. This process causes much movement of the surface of the soil and seed coverage, reducing or preventing freezing injury.

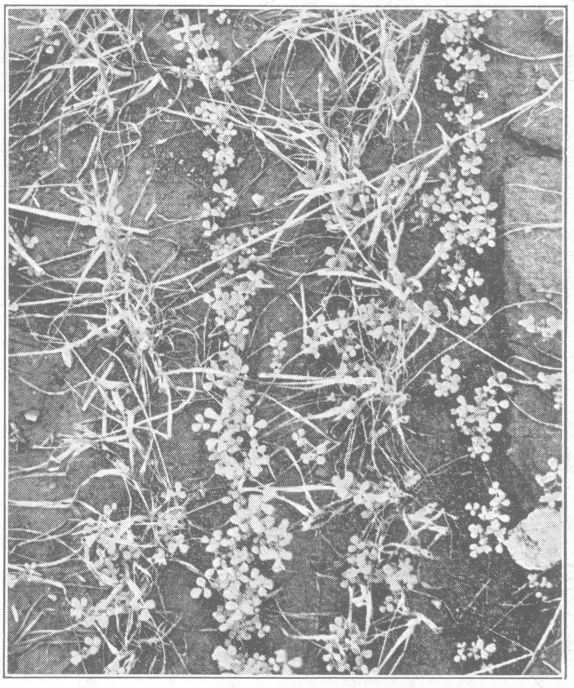

Fig. 22.—Split seedings divide the hazards.

Columbus, July 8, 1934. Half the seed sown broadcast on March 12, 1934; half drilled on March 31, 1934. Plants from each seeding are clearly visible.

An additional factor, and a very important one in obtaining stands at this time, is the moist condition of the surface soil which promotes prompt germination and establishment as soon as the temperature rises a few degrees above freezing. Even in the absence of freezing and thawing, seeds will germinate and establish themselves on moist soil, especially if rain falls and washes just a little soil over the seeds. It is true that it is easier to tramp over a frozen soil than over a muddy one, but that is about the only good reason for choosing the honeycombed condition for the job. When seed is sown in wheat, the earlier the seedling is able to start growth, the more chance it has to get started in time to compete with the wheat. The biennial and perennial forage crops grow at lower temperatures than many of the annual weeds, so that early seeding normally gets them started ahead of the weeds.

All of these factors work together to make it desirable to make spring seedings as early as possible, and still avoid freezing injury. Of course, we do not know in any given season just when a freeze is likely to come, but the advantage of early seeding is so great that it pays to take a considerable chance of freezing in sowing early.

At both Wooster and Columbus, the most favorable dates for seeding red clover have been about March 1 to 20, for alfalfa and scarified sweet clover, March 10 to 30. Drilling at the earliest possible date has been practically as successful with all of these crops, but it is not, usually, farther south on wet soil types.

Split seedings.—In order to obtain the advantages of early seeding and yet not hazard all of the seed on early seeding, a method has been suggested which is now standard on the outlying experimental farms. This consists in sowing half the seed broadcast early (March 1 to 15, depending upon the section of the State) and the rest 2 or 3 weeks later, either broadcast or with a drill, as conditions permit (Fig. 22). This is one of the most generally reliable methods we have tried although, of course, when conditions are favorable for some one method of single seeding, that one will give a better stand in that year than the split seeding.

SUMMER SEEDINGS (LATE JUNE, JULY, AND AUGUST)

By far the most reliable hay legume for summer seeding is alfalfa. If the soil will produce alfalfa at all, it should be included in the summer seeding mixture, and such seedings are far surer when alfalfa makes up a generous proportion of the mixture. Red clover, alsike, and the grasses are more sensitive to summer heat and drouth than alfalfa, and often do not establish themselves well at this time (Fig. 23). However, timothy will establish itself well enough that it is usually better to sow it along with the legumes than later, where it is to be in the mixture. If it should fail to catch at this time it can be drilled into the legume stand in late September very satisfactorily. Broadcasting timothy in September on a summer-sown seeding has usually failed.

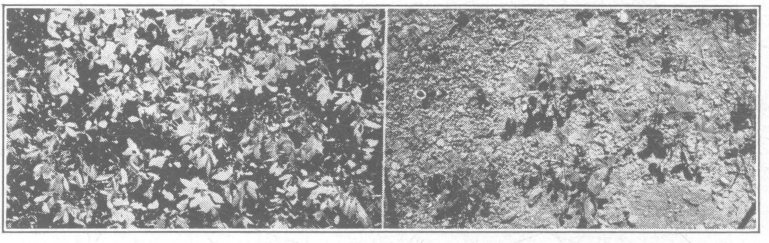

Fig. 23.—Red clover is a poor crop to sow in hot weather.

Columbus, September 9, 1936. Left, alfalfa; right, red clover (the latter with weeds removed before photographing). Sown June 10, 1936, alone. Clipped August 11. Alfalfa 10 to 12 inches high; red clover 3 to 5 inches high. Similar results were obtained from a July 8 seeding.

Summer seeding serves several purposes. On very weedy ground, it permits working the ground for 2 or 3 months before seeding and, so, getting rid of most of the weed seeds in the surface soil. However, sloping land which is

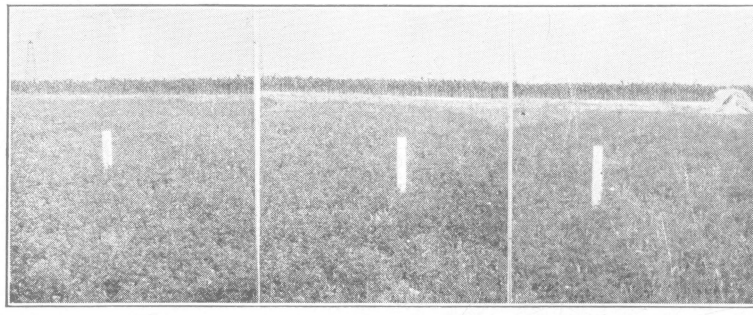

Fig. 24.—Reseed stubble land in July or early August.

Wooster, July 14, 1936. Stands of alfalfa sown on wheat stubble land after harvest. Left, sown July 11, 1935. Center, sown August 19, 1935. Right, sown September 4, 1935

	Yields per acre in 1936			
	Left	Center	Right	
	Lb.	*Lb.*	*Lb.*	
First cutting	2820	960	240	
Second cutting	2520	1920	1500	(weedy)
Total	5340	2880	1740	

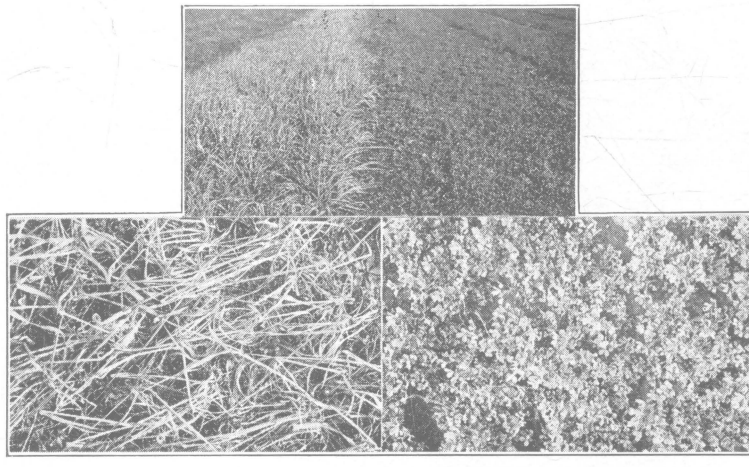

Fig. 25.—Use no small grain with summer seeding.

Columbus, December 5, 1934. Alfalfa sown August 13, 1934. Top left, sown with 4 pecks of Fulghum oats; top right, sown alone Columbus, March 27, 1935. Bottom, close-up of same plots as at top

fallowed for some time in preparation for summer seeding is likely to erode badly. There is more opportunity in a summer seeding on fallowed ground to work lime and fertilizers into the soil and prepare a suitable seedbed. An important advantage of summer seeding is that the large amounts of superphosphate and potash which it may be desirable to use in starting alfalfa can be applied directly for that crop; whereas if they are applied to a small-grain companion crop, the latter may make such a rank growth as to injure the alfalfa.

The basic hazard of summer seeding is lack of moisture. In the hot, dry summer days, especially on soils which do not furnish water readily, the soil rapidly dries below the permissible depth of sowing small forage seeds. If there has not been opportunity before that time for germination and the establishment of seedlings, many of the seeds die. In a summer seeding, seeds which remain on the surface after the first rain are practically always a total loss.

In addition to this fundamental hazard, the root systems of plants in summer seedings are never as deep or as well stored with food reserves before winter as are those of spring seedings in the same season, and winterkilling is more common as a consequence. In practice, summer seeding often means that there is no return from the land for 1 year. It is usually more expensive and more difficult to prepare a suitable seedbed in the summer than in the spring.

June seedings are not usually satisfactory. It is too late for the use of a companion crop, and yet it is seldom that most of the weed seeds in the surface soil have germinated before the date of seeding, so that the weed problem is nearly always serious in June seedings, or May seedings in the southern part of the State. If the weed problem is not serious, May-June seedings of alfalfa, or sweet clover if it becomes established, are entirely satisfactory. Seedings of the grasses, red clover, and alsike clover are not usually as satisfactory at this time as later in the summer because they are sensitive to the effects of summer heat, and sown at this time they have to endure the entire hottest period with a minimum start (Fig. 23).

Summer seedings of alfalfa and sweet clover should be made in July as soon as moisture conditions are favorable for the germination of the seed and the survival of the plants. There is some evidence that because of the sensitiveness of the clovers to heat, red and alsike clover are best sown after August 1, especially in the central and southern parts of the State. Legume seedings made after mid-August may not make enough growth in the fall to survive the winter (Fig. 24).

If sown after mid-August, legume-grass mixtures are more likely to survive than are legumes alone, because the grass protects the small legume seedlings to some extent against winterkilling and loss by heaving in the spring. Some timothy or other grass should ordinarily be included in all such late seedings. If a sufficient stand of the legume fails to survive the winter, more seed can be sown in the spring.

No companion crop should ever be used with a summer seeding. The suggestion has frequently been made to sow oats with such a seeding, supposedly in order that the growth may make a mulch for the winter. How this worked out at Columbus in a typical case is illustrated in Figure 25. There was an abundance of mulch here but the yields of hay per acre the next year were:

	Pounds per acre	
	Sown in oats	Sown alone
First cutting	3,370	5,170
Second cutting	2,990	3,950
Third cutting	2,880	2,890
Total	9,240	12,010

The summer-sown oats shaded and smothered many of the seedlings.

In sowing in the summer, it is often a question whether to sow in dry soil and trust to the next rain to sprout the seed or to sow after a rain. The advantage of sowing in a dry soil is that when the rain does come, the seeds can germinate at once; whereas if they are not sown, it is necessary to work up the soil and sow the seed after the rain. By the time this is done, the topsoil in which the seeds are sown is too dry to germinate them, and they do not come up until the next rain. Among the many summer seedings at Columbus, even when sown following a rain, seeds have seldom germinated until after another rain. Where they have germinated before a rain, the stand has been poor, because many seedlings have died from lack of water before establishment.

On the other hand, the same thing can happen if, after seeding in dry soil, the first rain is a light one. Of course, there is no question but that seeding should be delayed if there is no reserve moisture in the soil; this discussion refers only to the surface soil. With mulching after seeding, it is probable that seeding in dry surface soil would be generally safer than trying to seed just after a rain.

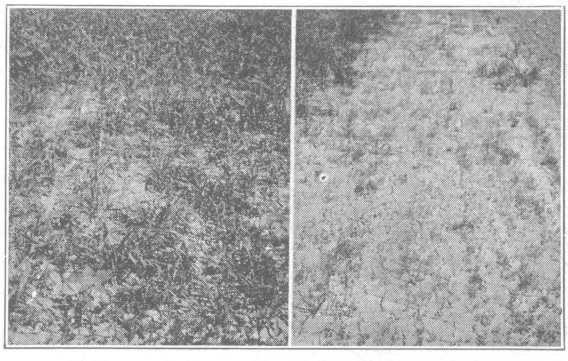

Fig. 26.—Preparing seedbed some time before seeding permits killing volunteer grain.

Columbus, September 9, 1936. Oats stubble prepared for seeding by disking. Left, sown August 8, 1936; right, sown August 22, 1936

Seeding after small-grain harvest.—When spring seedings fail in a small-grain crop, it is sometimes possible to make good the loss by seeding after grain harvest. Although the soil moisture supply is likely to be low (and this makes the practice more or less uncertain), an increasing number of farmers are finding seeding alfalfa at this time more certain than sowing in thick and productive stands of wheat in the spring. The soil should be prepared as soon

after grain harvest as possible. Disking clean stubble land is generally preferable to plowing, since a firmer and more uniform seedbed is usually obtained. If plowing is done to destroy weed growth it should be shallow, and the plowed land should be worked down at once with a disk and cultipacker or heavy roller in order to pack the soil and reduce the loss of moisture to a minimum.

Seedings made immediately after small-grain harvest may suffer from weeds or a volunteer crop of grain (Fig. 26). This trouble may be greatly reduced by fitting the seedbed immediately after harvest, permitting the weeds or volunteer grain crop to sprout, and then killing the weeds or volunteer grain off by cultivation. Plowing the stubble will reduce the amount of volunteer grain (Fig. 27).

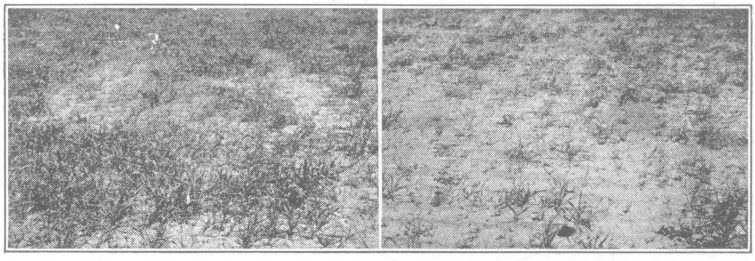

Fig. 27.—Plowing reduces amount of volunteer grain.

Columbus, September 9, 1936. Oats stubble seeded to meadow mixture August 8, 1936. Left, seedbed prepared by disking; right, seedbed prepared by plowing

The time of making the seeding should be governed by the moisture supply and the growth of weeds and volunteer grain. For example, wheat stubble land may be prepared in mid-July and seeded down the first or second week in August. Oats stubble land may be prepared late in July and sown as soon after that as the weeds and volunteer grain crop can be controlled. Oats stubble land is generally somewhat looser than wheat stubble land, especially if the land was spring-plowed for oats, and if late May and June have been dry so that the land is not weedy, the forage seed can be drilled directly into the stubble without any previous seedbed preparation. Volunteer oats are not likely to be as troublesome with this method as where the stubble land is disked or harrowed and many shattered oats are covered. However, if weeds are present, they may outgrow the forage seeding if the soil is moist and cause a failure of the forage stand.

If soybean hay is harvested by August 1, alfalfa or alfalfa-timothy mixtures may be sown at once with little labor for seedbed preparation. Even cut this early, soybeans will produce a ton to a ton and a half of hay, which gives some return from the land before seeding the alfalfa.

FALL SEEDINGS (SEPTEMBER AND OCTOBER)

Fall seedings are usually of timothy or other grasses sown with winter wheat. No legumes should usually be sown after September 1 except sweet clover with a high proportion of hard seeds. On the other hand, September 1 to October 15 is the most favorable period for sowing almost all grasses. Orchard grass, which is sometimes winterkilled, is an exception, but even orchard grass is frequently successful when sown in the fall. Kentucky bluegrass is so much safer when sown at this time that every possible effort should

be made to sow lawns, pastures, and any other seedings containing bluegrass in the fall. Bluegrass does not form the rootstocks which constitute a true sod until it has gone through a winter. Timothy is much more certain when fall-sown than when spring-sown. A large proportion of Ohio seedings contain timothy and are made in wheat, and the universal practice of sowing timothy in the fall in wheat is abundantly justified. It is possible, however, to sow too much timothy in the fall, and this results in a reduction in the yield of the legume part of the mixture (Table 11).

Timothy may be sown in the fall (omitting the wheat), and legume seedings may be made on the timothy in the spring just as if wheat had been sown. A light crop of hay may be harvested in the place of a wheat crop. The yield of hay the following year may be slightly larger than where the seedings were made in wheat (Table 8).

TABLE 8.—Yields of Hay from Seeding Timothy and Alfalfa Alone and in Combination, with and without a Companion Crop of Wheat. Wooster

Year sown	Year harvested	Yield per acre: Hay Lb.	Yield per acre: Wheat Bu.	Year harvested	Yield of hay per acre: First cutting Lb.	Yield of hay per acre: Later cuttings Lb.	Yield of hay per acre: Total Lb.
Timothy sown in the fall without a companion crop							
1933.....	1934	1000*	.....	1935	4350*	870*	5,220
1934.....	1935	2940*	.....	1936	1965*	None	1,965
1935.....	1936	2130*	.....	1937	6150*	690*	6,840
	Average	2023*	.....	.....	.....	.....	4,675
Timothy sown in the fall, alfalfa in the spring, without a companion crop							
1933-1934...	1934	1200† (light mixed)	.....	1935	6690† (41% timothy)	4570§	11,260
1934-1935...	1935	3120† (86% timothy)	.....	1936	3780† (47% timothy)	2610§	6,390
1935-1936...	1936	2419† (82% timothy)	.....	1937	8010† (60% timothy)	3630§	11,640
	Average	2246†	.....	.....	.....	.....	9,763
Alfalfa sown in the spring without a companion crop							
1934.....	1934	None	.....	1935	4860§	3960§	8,820
1935.....	1935	None	.....	1936	3340§	2130§	5,470
1936.....	1936	None	.....	1937	7890§	3570§	11,460
	Average	.....	.....	.....	.....	.....	8,583
Timothy sown in the fall with wheat, alfalfa sown in the spring							
1933-1934...	1934	.....	23‡	1935	6090† (23% timothy)	4800§	10,890
1934-1935...	1935	.....	39‡	1936	2910† (52% timothy)	2310§	5,220
1935-1936...	1936	.....	25‡	1937	8370† (61% timothy)	2790§	11,160
	Average	.....	29‡	.....	.....	.....	9,090
Alfalfa sown in the spring in wheat							
1933-1934...	1934	.....	23‡	1935	4440§	5400§	9,840
1934-1935...	1935	.....	39‡	1936	3340§	1980§	5,320
1935-1936...	1936	.....	25‡	1937	6090§	3480§	9,570
	Average	.....	29‡	.....	.....	.....	8,243

*Timothy.
†Mixed hay.
‡Average wheat yields include those from comparable near-by plots.
§Alfalfa.

Table 8 gives the yields of hay and of wheat in an experiment at Wooster now under way.

Approximately 3000 pounds of hay replaced about 30 bushels of wheat when timothy and alfalfa were sown. Of this amount 2246 pounds of very light mixed hay replaced the wheat crop directly and the remainder was from the larger yield of the first cutting on the "no companion crop" plots the following seasons. Omitting the wheat crop is not likely to be an economical practice unless the price of wheat is low and that of hay, high.

Sowing timothy alone without a companion crop of wheat gave an increase of 1600 pounds of timothy hay over sowing it with wheat in one comparison only (not reported in Table 8).

Omitting the wheat and sowing alfalfa alone the following spring on the fall-prepared seedbed gave no increase over using the wheat companion crop when alfalfa was sown on the latter by the best method.

Losses from heaving are likely to be greater if timothy is sown alone than if it is sown with wheat. Seedings made late in August or early in September will usually survive the winter, especially if protected by a mulch of straw or manure applied early in the winter. Early seeding, heavy seeding, and mulching will retard erosion losses, which are likely to be excessive on sloping land protected only by fall-sown timothy.

There may be special circumstances under which it is necessary or desirable to sow timothy or timothy-grass mixtures in the fall without a companion crop. In general, however, it will be more desirable to use the companion crop of wheat.

The cultipacker method of seeding[8] is ideal for sowing timothy seed in the fall without a companion crop or may be used immediately after the wheat has been sown.

The grass-seed attachment of the grain drill may be used to sow the timothy seed, but care should be exercised not to cover the seed too deep.

WINTER SEEDINGS (NOVEMBER TO MID-FEBRUARY)

Sweet clover in the hull can be sown at, or any time after, wheat seeding (19). Winter seedings of red clover, and even alfalfa, are sometimes successful, but with these crops, which contain a higher proportion of permeable seeds, it is much more desirable to wait until very late winter or early spring to make the seeding.

RATES OF SEEDING

The rate of seeding should be enough to give a satisfactory stand, and, for the sake of economy in seeding, no more. The Experiment Station has conducted rate-of-seeding tests with alfalfa (20) and sweet clover (7), of which brief summaries are given in Tables 9 and 10.

The standard rate of seeding recommended for alfalfa and sweet clover is 10 to 12 pounds per acre. More than 15 pounds is unnecessary and less than 7, unsafe. Neither the protein content nor the proportion of leaves in the hay has been increased by rates of seeding alfalfa above 10 pounds per acre.

When timothy is sown in wheat in the fall, to be followed by clover or alfalfa in the spring, the rate of seeding timothy should not exceed 3 pounds; else the proportion of clover in the hay and the yield of hay, both in the year after seeding and the next year, will be reduced (Table 11) (4).

[8]Discussed in detail under "The cultipacker method".

TABLE 9.—Rates of Seeding Alfalfa

Rate of seeding per acre	Wooster 5-year average yield of hay per acre, two tests	Northwestern Experiment Farm, Holgate 2-year average, two tests		
		Yield of hay per acre	Leaves in hay	Average protein in hay
Lb.	*Lb.*	*Lb.*	*Pct.*	*Pct.*
5	8800	3440	56.6	17.8
10	9000	3900	56.4	18.3
15	8600	4020	56.7	18.3
25	7440	4020	55.0	18.1

TABLE 10.—Rate of Seeding Sweet Clover with Oats, Wooster, and Yield of Sweet Clover Hay Cut in June

Scarified seed Rate per acre	Four-year average yield per acre
Lb.	*Tons*
2½	1.96
5	2.24
10	2.40
15	2.39
30	2.31

TABLE 11.—The Time and Rate of Seeding Timothy in Wheat, Timothy Breeding Station, North Ridgeville, Ohio*

The yields and proportion of timothy and clover are summarized for the first and second hay years in three series of experiments (1925-1930). Ten pounds of red clover seed were sown in the spring on all plots except the last.

Timothy seeding		Yield of hay per acre								
		First year							Second year (Total) (Timothy)	Total hay in two seasons
		First cutting					Second cutting (clover)	Total		
Time	Rate	Timothy		Clover		Total†				
	Lb.	*Lb.*	*Pct.*	*Lb.*	*Pct.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Fall	1¼	1165	39.9	1725	59.1	2919	1538	4457	2768	7225
Fall	2½	1340	43.9	1688	55.3	3053	1526	4579	2744	7323
Fall	5	1403	47.9	1520	51.9	2929	1525	4454	2656	7110
Fall	10	1486	56.2	1153	43.6	2644	1436	4080	2448	6528
Spring	10	1155	39.1	1781	60.3	2953	1590	4543	2527	7070
Fall and spring‡	2½ + 7½	1377	46.9	1548	52.7	2937	1522	4459	2608	7067
Spring (Clover only)	0	74§	3.2	2183	93.9	2325	1437	3762	1042§	4804
Fall (Timothy only)	10	1376	98.9	12‖	0.9	1391	129‖	1520	1528	3048

*Conducted cooperatively by the Ohio Agricultural Experiment Station and the Division of Forage Crops and Diseases of the United States Department of Agriculture. Taken from partially unpublished experiments of M. W. Evans and F. A. Welton to be published in detail in a forthcoming bulletin of the Ohio Agricultural Experiment Station.

†Includes some weeds.

‡Split seeding.

§Volunteer timothy.

‖Volunteer clover.

The effect of sowing more than 2½ pounds per acre of timothy in the fall on wheat where clover was sown in the spring was to decrease the yield of the mixed hay the first year of harvest, to decrease the yield of the clover fraction of the mixed hay, to decrease the proportion of clover in the mixture, and to decrease the yield of the clover aftermath. The effect on the second-year meadows was to decrease the yield of timothy. Three pounds of timothy per acre in the fall has been uniformly satisfactory at Wooster in a large number of trials for many years. In the southern half of the State slightly higher rates of seeding timothy, up to 5 pounds, may be advisable in the fall.

RATES OF SEEDING FORAGES

Suggested average rates and dates of seeding the more important forage crops in Ohio are given in Table 12. The normal rates suggested in this table are those which experience and experiment have found to be generally satisfactory. Where seeding conditions are poor, as in a poorly prepared seedbed, or when sowing in corn, where much of the seed will probably be lost, or where especially thick stands are desired, rates up to the suggested maximum may be used. Of course, soil conditions which cause the failure of seedlings, such as lack of lime or nutrients, cannot be compensated for by sowing more seed. Where seeding conditions are exceptionally favorable or seed is unusually high priced, rates down to the minimum may be used, with greater risk of unsatisfactory stands.

THE SEEDBED

Poor seedbeds are responsible for many failures of seedings. The ideal seedbed for forage seeds has: (a) an abundance of moisture in the plowed layer and subsoil, (b) firm, compact soil under the seeds, (c) sufficient fine but granular soil at the top to cover the seeds, (d) the plowed layer well connected with the subsoil with no layers of trash between them. These requirements are always important but are of maximum importance for summer and fall seedings. In the spring, fairly loose seedbeds may sometimes be entirely satisfactory, since the considerable amount of rain and low evaporation at that time often settles the seedbed and prevents the failure which often follows loose, open seedbeds at other times of year. If there is sufficient rainfall following seedbed preparation, loose seedbeds may be satisfactory even in the summer—witness occasional good seedings in corn at the last cultivation.

For summer and late spring seedings it is desirable to prepare the seedbed sometime before seeding and keep it worked to compact the soil and kill weeds. In the summer, disking is frequently preferable to plowing as a means of preparing for a new seeding. Late spring- and summer-plowed land is difficult, and sometimes impossible, to work down and firm uniformly; at best it requires considerable time and labor. As a result, the stand may be patchy. If disking is done fairly shallow, a uniform packing of the soil may be accomplished by harrowing and cultipacking. The method of cultipacking just before broadcast seeding is particularly adapted to obtaining firm soil under the seeds.

COVER SEEDS, BUT NOT TOO DEEP

Forage seeds should be covered, but not too deep. The greater the natural looseness of the soil, the deeper the coverage should be within limits of ¼ to 1 inch. Any drilled seeding on loose ground must be carefully watched or it will be covered too deep.

TABLE 12.—Suggested Rates and Dates of Seeding the More Important Forage Crops in Ohio

Crop	Weight per bushel		Rate per acre				Date of sowing	
			Alone			In mixtures	Northern Ohio	Southern Ohio
	Legal	Actual (good seed)	Minimum	Average	Maximum			
Alfalfa	.....	60–63	7	10–12	15	2–10	Mar. 15–Apr. 30 or July 1–Aug. 15	Mar. 15–Apr. 15 or July 1–Sept. 1
Bluegrass, Kentucky	14*	19–28	.....	.....	.....	2–10	Aug.–Sept. or Mar.–Apr.	Sept.–Oct. or Mar.–Apr.
Bluegrass, Canada	14*	14–24	.....	.....	.....	2–10	Aug.–Sept. or Mar.–Apr.	Sept.–Oct. or Mar.–Apr.
Brome grass	.....	15–20	10	15	20	5–10	Aug.–Sept. or Mar.–Apr.	Aug.–Sept. or Mar.–Apr.
Clover, alsike	60†	60–66	3	4–5	8	2–4	Mar.–Apr. or July 15–Aug. 15	Mar. or Aug.
Clover, crimson	60†	60–63	10	15	20	5–10	Do not use	Not in spring; July–Aug. 15
Clover, medium and mammoth red	60†	60–63	6	8–10	12	2–6	Mar.–Apr. or July 15–Aug. 15	Mar. or Aug.
Clover, sweet, scarified	60†	60–63	7	10–12	15	.....	Mar. 15–Apr. 30; not in summer	Mar. 15–Apr. 15; not in summer
Clover, sweet, dehulled, but not scarified	.....	55–60	10	15	20	.....	Mar. 1–31; not in summer	Feb. 15–Mar. 15; not in summer
Clover, sweet, in-the-hull	.....	30–40	15	20–24	30	.....	Feb. 15–Mar. 15; not in summer	Feb.; not in summer
Clover, white	60†	60–63	.....	.....	.....	½–2	Mar.–Apr. or July 15–Aug. 15	Mar. or Aug.–Sept.
Lespedeza, Japanese	.....	25–29	10	15	25	2–5	Do not use	Late Feb.–Mar.; not in summer or fall
Lespedeza, Korean	.....	40–45	10	15	25	2–5	Do not use	Late Feb.–Mar.; not in summer or fall
Meadow fescue	.....	24–30	10	15	20	5–10	Sept. or Mar.–Apr.	Sept.–Oct. or Mar.–Apr.
Orchard grass	14*	14–22	10	15	25	5–8	Late Mar.–Apr. or Aug.	Mar.–Apr. or Aug.–Sept.
Redtop	14*	30–40	4	7	10	1–4	Aug.–Sept. or Mar.–Apr.	Sept.–Oct. 15 or Mar.–Apr.
Reed canary grass	.....	44–48	4	8	12	5–10	Aug.–Oct. or Mar.–Apr.	Sept.–Oct. or Mar.–Apr.
Timothy	45†	45–50	2–4‡	4–8‡	8–12‡	2–4–8	Aug.–Sept. or Mar.–Apr.	Aug.–Oct. 15 or Mar.–Apr.

*Other states. †Ohio. ‡Larger amounts for spring seeding.

DRILLING VERSUS BROADCASTING FOR COVERAGE

For early seedings, broadcasting is the only possible method. It is not possible to cover mechanically very early spring seedings on wheat or other fall-prepared land, but some covering of the seed is accomplished at these times by freezing and thawing. Covering at this time is not essential except as a protection against the killing of the uncovered sprouted seeds by freezing, since the seeds can establish themselves on the moist surface. Because early seeding is so important, broadcast seedings often have an advantage over drilled seedings. In southern Ohio, on soil types which dry out slowly (a conspicuous example is the Clermont silt loam), experiments of several years have shown drilling legumes in wheat, which must of necessity be done late, to be very much inferior to broadcasting, which can be done early. The farther north one goes, the less difference there is in this respect.

After the soil is dry enough to work, coverage becomes increasingly important and broadcasting, correspondingly unreliable (Fig. 20). Broadcasting after the soil is workable should be used only on recently prepared seedbeds which are sufficiently loose on top that the seed will be sufficiently covered by falling into the interstices of the soil and will be brought into close contact with the soil by the next rain. Therefore, when sowing in wheat late in the spring is practiced, drilling is preferable to broadcasting as soon as the ground is dry enough to permit drilling (Tables 13 and 14); whereas in oats the seed may be broadcast at practically any time oats are sown.

TABLE 13.—The Importance of Covering Seed

Methods of seeding alfalfa on wheat—Wooster (Fig. 20)
Twelve and one-half pounds of alfalfa seed per acre

Plot No.	Date and method of seeding on wheat, 1934	Oct. 10, 1934 Plants per square yard	Yields of hay, 1935			
			First cutting	Second cutting	Third cutting	Total
		No.	*Lb.*	*Lb.*	*Lb.*	*Lb.*
5	Broadcast, March 6	258	4620	3180	1890	9690
6	Broadcast, April 2	376	4440	3300	2100	9840
7	Broadcast, April 25	29	3750	2190	1560	7500
8	Drilled, April 25	97	4410	3060	2070	9540

If a drill is not available, fairly good results can be obtained by broadcasting the seed on the wheat and covering it with a harrow. On firm soils it may be necessary to lap the harrow in order to loosen enough soil for seed coverage. The rotary hoe is ineffective in covering the seed on firm soils; it works fairly well on naturally loose soils.

In a dry spring, it may be desirable on some firm soils to harrow after drilling in order to cover the seed more effectively.

TABLE 14.—Methods of Seeding Sweet Clover on Wheat—Wooster

Ten pounds of scarified seed per acre, sown April 20 to May 4

Method of seeding	Yield of hay, 5-year average
	Lb.
Broadcast only	3680
Broadcast and harrowed in	4240
Drilled	4180
Rotary hoed twice	3660

The grass-seed attachment to the ordinary grain drill is perhaps a little less useful than the special grass-seed drill because of the tendency to deeper planting and the wider spacing of rows. However, on wheat ground, where on many soils the problem is getting the seed covered rather than covering too deep, excellent stands can be obtained by its use. On newly prepared ground the attachment should be used to broadcast the seed on the surface, not to put it through the grain tubes (Fig. 4). Even when set to broadcast, many grain drills are so arranged that the forage seeds fall in front of the grain disks or hoes and, consequently, many of the seeds are covered too deep. Such drills are greatly improved by attaching extra-length delivery tubes to the grass-seed attachment, so that the forage seed is broadcast back of the grain disks.

The effect of too deep seeding is illustrated by a test at the Northwestern Experiment Farm in 1936 in which alfalfa was sown in oats by broadcasting and by drilling. Fifteen broadcast plots averaged 151 alfalfa plants per square yard and the drilled plots, 81 plants per square yard.

The disk-type grass-seed drill is ideal for sowing seed on a settled soil. This is an implement which a group of farmers might well own in common. Even the special 4-inch grass-seed drill may plant seed too deep in loose ground, and great care must be taken to regulate it to plant sufficiently shallow. It is often helpful or necessary to file another notch on the depth-regulating quadrant to effect shallower planting.

THE CULTIPACKER METHOD

An excellent method of seeding on any recently and well-prepared seedbed is to (a) cultipack the soil, (b) sow the seed broadcast, and (c) run a harrow or weeder lightly crosswise or cultipack again to cover the seed. Most of the seed falls on the firm, moist soil at the bottom of the cultipacker furrows, is covered

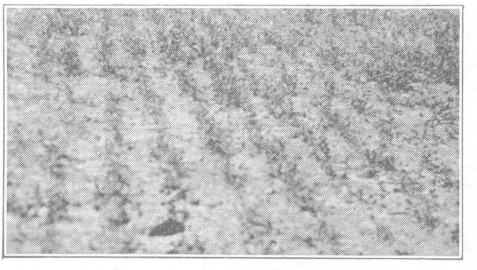

Fig. 28.—Alfalfa sown broadcast after cultipacking

Farm of P. E. Grubb, Johnstown, Ohio. Appearance 33 days after seeding. Photo from P. E. Grubb

uniformly and at a shallow depth, and comes up in rows as though drilled (Fig. 28). This method is especially valuable in summer seedings, but may be used any time that the soil is dry enough not to puddle or lose its granular structure under the cultipacker. At Columbus, this method has repeatedly been superior to drilling in summer seedings (Table 15).

USE OF THE CULTIPACKER AFTER SEEDING

Attempts are often made to obtain a firm seedbed by rolling or cultipacking after seeding. As just noted, it is far more important to have the soil under the seed firm. If that is accomplished, it is very seldom that packing the earth above and around the seed has a favorable effect. If cultipacking is followed by a dashing rain on a soil which tends to bake, the result may be a crust that will prevent the emergence of many seedlings. A 3-year trial of cultipacking broadcast seedings in oats at the Northwestern Experiment Farm at Holgate showed no effect, either favorable or unfavorable, on the stands obtained.

TABLE 15.—Methods of Summer Seeding, Columbus, 1936 (Fig. 33)

Method of seeding	Plants per square yard		
	Alfalfa	Red clover	Timothy (not counted)
	No.	*No.*	*No.*
Sown with grass-seed attachment on a grain drill	103	0	Very few
Sown broadcast after cultipacking and covered lightly with harrow	182	38	Few
Same as 2, but mulched with straw or manure immediately after seeding	198	137	Many

Repeated comparisons in summer seedings at Columbus of covering with a cultipacker and covering with a weeder or harrow, have failed to show any advantage for cultipacking after seeding. Almost the only opportunity for cultipacking after seeding to result in better stands is when a loose seedbed is compacted by the cultipacker and a very light rain, just enough to germinate the seeds, follows. Then the seedlings may establish themselves in the cultipacked soil; whereas in the loose soil, the seedlings may dry out before they become established.

MANURE AS AN AID IN OBTAINING SEEDINGS

On most soils the more general use of manure as a winter top-dressing on wheat, applied at the rate of five to six spreader loads per acre, would go a long way toward ensuring legume stands in the wheat. Such a coating of manure conserves surface soil moisture, provides seed coverage, protects the small seedlings from drying, provides available plant nutrients near the surface of the soil within easy reach of the seedling roots, reduces the severity of fluctuations in soil temperature, and protects the wheat and young forage plants against heaving.

Winter wheat on the outlying experiment farms of the Ohio Agricultural Experiment Station has been top-dressed in December with an average of 4½ tons of manure per acre. This has increased the yield of wheat an average of 6 bushels per acre and the following hay crop by an average of 850 pounds. On three county experiment farms in eastern Ohio the increases in yield were 9.7 bushels of wheat and 1110 pounds of mixed hay.

Manure is also helpful when applied to the seedbed and disked in, or applied in the summer as a top-dressing on new seedings.

Manure has been applied to different crops in a 4-year rotation of corn, oats, wheat, and clover at Wooster. The effect of these applications on the yield of wheat and clover is given in Table 16.

The data indicate no great difference in the returns from manure applied to the different crops in the rotation. It is evident, however, that placing a part or all of the manure on the wheat or new clover seeding materially improves the hay crop and, on this land, is preferable to putting all of the manure on corn.

In the test reported in Table 16, the manure applied to the wheat was disked into the seedbed before the wheat was sown. This has a tendency to increase the growth of straw in some seasons.

Using the manure as a winter top-dressing on the wheat will prevent much of the lodging which occurs when the manure is applied to the seedbed and at the same time will be a great benefit to the legume stand in the wheat. By

TABLE 16.—Manure Applied to Different Crops in a 4-year Rotation Experiment, 21, 1928-1934, Wooster

Rotation: Corn, oats, wheat, clover. Basic treatment—all plots received ground limestone on corn and, in addition, manured plots received 192 pounds of 20 per cent superphosphate on both corn and wheat.

Plot	Shed manure applied				Increase in yield, 7-year average*				Value of increase*
	Corn	Oats	Wheat	Clover	Corn	Oats	Wheat	Clover	
	Tons	*Tons*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Dol.*
32	4	.....	4	.....	21.1	8.7	16.8	1440	38.46
33	8	.....	.....	.....	18 7	8.7	15.7	1208	34.87
35	.....	.....	8	.....	15.5	8.0	19.0	1840	38.80
36	.....	.....	.....	8	17.9	10.5	15.2	1860	37.92

*Increases are for both manure and superphosphate over unfertilized checks (limed only).

assisting in obtaining better stands of legumes, the manure applied as a top-dressing to the wheat is generally fully reflected in the corn crop obtained after the sod is plowed.

The results of top-dressing wheat with manure compared with plowing it down for wheat are given in Table 17. In this experiment, applying manure as a winter top-dressing on the wheat increased the yield of clover hay about ½ ton and the corn yield 2 bushels per acre over plowing it down for the wheat, but the wheat yield was about 2 bushels per acre less.

TABLE 17.—Effect of Applying Manure for Wheat at Different Times on the Yield of Clover Hay

Experiment No. 32, Wooster

Rotation: Corn, soybean hay, wheat, clover

Basic Treatment: One ton of limestone on sod for corn; 400 pounds of 20 per cent superphosphate on both corn and wheat

Treatment	Clover hay (7-year average)	
	Yield per acre	Increase*
	Lb.	*Lb.*
Crops fed, one-half of the manure applied to corn and one-half applied before plowing for wheat	3373	389
Crops fed, one-half of the manure applied to corn and one-half applied as winter top-dressing for wheat	4274	1439
Oats substituted for soybeans in the rotation. Crops fed, one-half of the manure applied to corn; one-half applied as winter top-dressing for wheat	4232	1361

*Increase over adjacent check plots receiving basic treatment only, no manure.

MULCHES

It is hard to overestimate the value of mulches in obtaining seedings. Part of the value of manure is as a mulch, and other materials can be used as mulches to help the new seedings. Mulches affect the stand obtained in many ways, all favorable. In winter and early spring seedings they protect the

Fig. 29.—Effect of manure on seeding in wheat at different dates

Wooster, September 15, 1936. Background, light top-dressing of manure applied January 29, 1936, to wheat; foreground, no manure. Left, alfalfa sown with wheat October 4, 1935. The manure saved only a few alfalfa plants; the damage was done before the manure was applied. Center, alfalfa broadcast January 14, 1936. The manure saved the stand. Right, alfalfa broadcast February 28, 1936. The effect of the manure is less noticeable because the stand was good without the manure. There was no winterkilling after this plot was seeded.

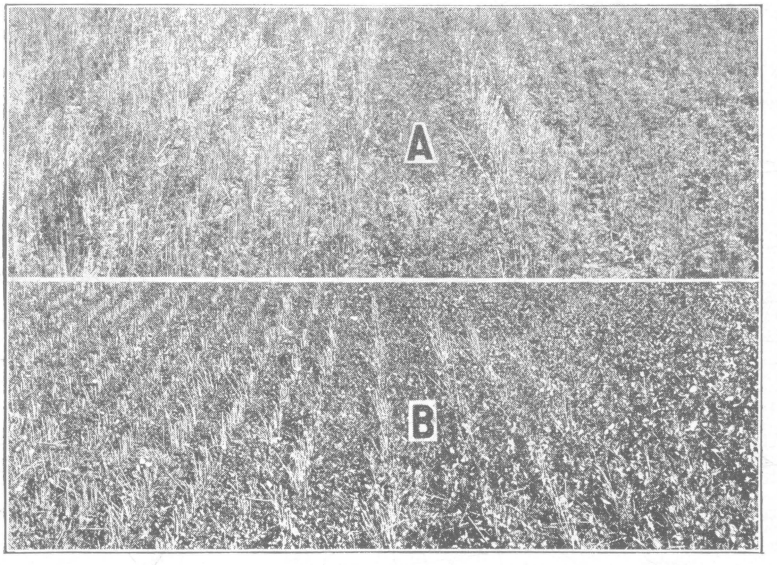

Fig. 30.—Mulching wheat with straw favors a legume stand.

Wooster. A—Appearance of alfalfa in August. Left, wheat not mulched; right, wheat mulched with straw in December. B—Appearance of red clover in November. Left, wheat not mulched; right, wheat mulched with straw in December

seedlings from cold, and, still more important, from freezing and thawing (Fig. 29). Almost any seeding in a winter grain will be increased if the grain is mulched with straw in December (Fig. 30). An extreme example of the value of mulch for winter protection was given by sowing alfalfa with the wheat in the fall. (This method of seeding has not given generally good results, and is not recommended). At Columbus in 1934, alfalfa sown in this way with unmulched wheat produced a stand of only 16 plants per square yard. Where the wheat was mulched just before Christmas with 1 ton of straw per acre, the stand was 94 plants per square yard. This was entirely due to winter protection.

Mulching wheat during the fall or winter with straw, stover, or other crop residue of low nitrogen content often reduces the growth and yield of the wheat because it reduces the amount of available nitrogen in the soil. This reduced growth favors a stand of legumes, especially on land which normally produces a rank straw growth accompanied by lodging (Fig. 31).

Fig. 31.—Effect of mulching wheat with straw

Wooster, July 10, 1926. A—No mulch, heavy straw growth, much shade. B—Mulched with 2 tons of straw per acre in December. Lighter straw growth favorable to stand of legumes, less shade

The effects of mulching wheat with straw during the fall and winter at Wooster are given in Table 18.

The hay was red clover before 1931 and alfalfa from 1931 to 1934, inclusive. The average yield of red clover hay was increased slightly for the 8-year period by a top-dressing with 1 ton of straw per acre, but 2 tons appeared to be excessive, especially if applied late. The alfalfa was benefited by the 1-ton application and also by the early 2-ton application. Occasionally the stand of forage was favored because the mulch prevented an excess straw growth, and at other times the straw mulch mitigated the effect of spring and summer drouth. The beneficial effects of the straw mulch were more pronounced some seasons than others.

Mulches conserve soil moisture near the surface. It is a common observation that soil stays moist longer under even a trace of mulch than where no mulch is used. When seedlings are struggling to establish themselves, this slight extra moisture often saves a large proportion of seedlings. At Columbus in 1936, the average stand of scarified sweet clover in wheat mulched on January 2 with 1 ton of straw was 100 plants per square yard; whereas that in unmulched wheat was 32 plants per square yard.

TABLE 18.—Mulching Winter Wheat with Straw, Wooster

Amount of mulch per acre and time of application	Yield per acre				
	Wheat 14-year average		Clover hay 8-year average	Alfalfa hay 4-year average	
	Grain	Straw		First cutting	All cuttings
	Bu.	*Lb.*	*Lb.*	*Lb.*	*Lb.*
No mulch	35.4	3600	4710	4090	5550
1 ton, early*	34.1	3550	4790	4180	5820
1 ton, late*	35.9	3480	5100	4390	6140
2 tons, early*	31.2	3160	4640	4570	6140
2 tons, late*	31.9	3230	4360	4100	5870

*Early, September or October soon after sowing wheat. Late, December or January.

There is little need for mulching oats with straw or similar materials to control rank growth although it might be helpful on dark, "growthy" soils where the oats crop lodges regularly. Thin rates of seeding the oats, and harvesting oats for hay are more logical control measures.

MULCHING FOR SUMMER SEEDINGS

An application of some sort of mulch to a summer seeding immediately after sowing will do more to insure its safety than any other one thing that can be done (Fig. 32). In addition to saving moisture at the surface, where the seedlings need it, such a mulch tends to prevent the formation of a crust both by breaking the force of the rain and by retarding drying of the soil, thus permitting the emergence of more seedlings; it reduces the temperature of the soil; and it protects the young stand against much winter heaving.

Such mulching is to be recommended on slopes and difficult situations generally, especially in seedings made for the control of erosion. However, it should often be profitable to spread some form of mulch on summer seedings on the average farm, as insurance against failure of this vital part of the farm program (Fig. 33).

In following this suggestion, three points are important:

1. The mulch should be put on at once after seeding. Delay may result in harm rather than good from the application.

2. The mulch must be light, about 1 to 1½ tons of straw or 4 to 6 tons of manure.

3. The mulch must be evenly spread. It is almost impossible to spread either straw or manure sufficiently evenly by hand.

PATCHING THIN STANDS

Because of the hazards of seeding, the feasibility of patching thin stands of forages is an important consideration. Two general principles may be noted: first, thin or uneven stands caused by insufficient lime or soil fertility are not likely to be repaired successfully until the condition is corrected; second, the younger the stand the more likelihood that patching it up will be successful.

Where a partial failure is due to drouth, as often happens to stands sown in companion crops in dry seasons, it is often possible, if good rains follow the removal of the companion crop, to repair them. Additional seed may be sown with a drill, if enough pressure is put on the disks to make sure that the seed

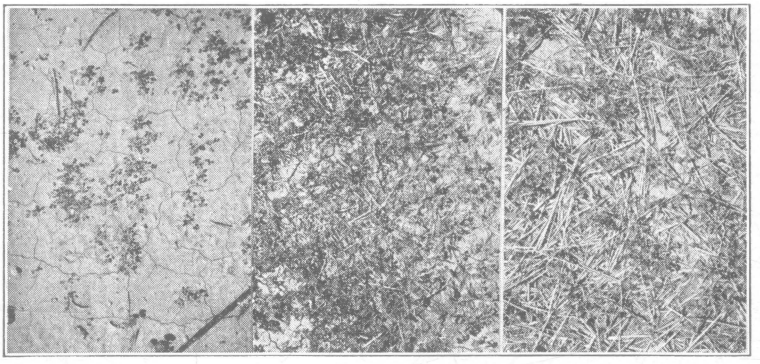

Fig. 32.--Mulching helps summer seeding.

Columbus, September 9, 1936. Mixture of alfalfa, 6 pounds, red clover, 6 pounds, timothy, 4 pounds per acre, sown broadcast in cultipacker furrows in disked soybean stubble and covered by a light harrowing (spike-tooth harrow, teeth slanted back). Left, no further treatment; center, top-dressed with 4 tons of manure per acre on the date of seeding; right, similarly top-dressed with 1 ton of straw per acre

Fig. 33.—Methods of summer seeding

Columbus, October 13, 1936. Mixture of alfalfa, 6 pounds, red clover, 6 pounds, and timothy, 4 pounds per acre, sown August 8, 1936. Left, sown with grass-seed attachment on grain drill, seed falling behind the grain disks; center, sown broadcast after cultipacking and covered lightly with a harrow; right, same as center, but mulched with 1 ton of straw per acre the same day as sown

is cut into the ground. With the single-disk grain drill frequently very little soil will fall back into the disk furrows, and the seeds will be left uncovered at the bottom of these shallow furrows. With this type of drill the success of this sort of reseeding depends on a timely rain to wash the soil back into the furrows and cover the seed. When this occurs within a week or two after seeding, some excellent reseedings have been made without materially injuring the stand already present. With the special grass-seed drill the furrows are narrow and steep, and on loose soil types, the seeds will generally be covered sufficiently to permit germination and establishment.

This method of reseeding in the summer is not successful when weeds are already established in the small-grain stubble, as they usually are after a wet June. Such stands are best left alone, or plowed and reseeded if too thin. Summer reseeding is much more successful with alfalfa than with red clover, and some alfalfa should be included in the reseeding mixture if the soil is at all favorable to the crop.

A thin summer seeding of alfalfa may sometimes be repaired by sowing more seed broadcast about the March 15 to 30 following, but this is rather uncertain.

If the stand of alfalfa or clover from earlier seedings is thin in September, the amount of hay the next year may often be increased by drilling timothy into the stand with a grass-seed drill or ordinary drill with grass-seed attachment; the seed must go through the seed tubes, not be broadcast. Broadcasting timothy on unprepared land at this time has usually been a failure.

CAN THIN ALFALFA BE RESEEDED WITH ALFALFA?

Because of the rather long life and gradual thinning out of alfalfa, this is a very common question. Attempts to reseed alfalfa in old, thin alfalfa have uniformly failed, although they have been made repeatedly under very favorable conditions. The old alfalfa plants, even if there are only a few per square yard, make such a shade that the young alfalfa seedlings are smothered out and have no chance to establish themselves.

SEEDING TIMOTHY IN THIN ALFALFA

However, it is possible to seed timothy in old, thin alfalfa and so prolong the usefulness of the meadow (18). The seeding is made after the final cutting of alfalfa is removed. This period is very favorable for starting timothy, and alfalfa usually does not make such a growth as to kill it out. It is desirable to prepare a seedbed, preferably by use of a spring-tooth harrow, or with a disk set to cut lightly, immediately after the final harvest for the season. The timothy is then broadcast or drilled, as may be most convenient. Drilling the timothy into the otherwise unprepared alfalfa (Fig. 34) has also been quite successful, and is, perhaps, to be preferred where bacterial wilt of alfalfa is present in the field. Broadcasting the timothy without seedbed preparation has always failed. Five pounds of timothy per acre has been sufficient. After the timothy is established, it occupies the bare spaces between the alfalfa plants, so that the total yield of hay at the first cutting is increased and the proportion of weeds is decreased.

Orchard grass has been successfully used in the same way, and it is probable that other grasses can also be sown in alfalfa, but timothy has the advantages of cheap seed, being readily sown with a drill, and starting well when sown in the fall.

Fig. 34.—Reseeding alfalfa with timothy

Columbus, November 4, 1935. Timothy drilled into thin alfalfa without other preparation, September, 1934

SUMMARY OF PRACTICAL SEEDING SUGGESTIONS

There are certain general requirements which must be met to obtain seedings at any time.

1. Choose a mixture or crop adapted to the specific soil and seeding conditions.
2. If lime is needed, it should be applied in preparing for a preceding crop or as early as possible in the preparation of the seedbed.
3. On many soils, but especially on those where it is difficult to obtain a stand, a heavy application of manure to the previous crop, or far enough in advance of seeding to permit mixing with the soil and partial decay, will greatly increase the chances for a successful seeding.
4. Inoculation of legumes must always be taken care of.

Under Ohio conditions, there are three general circumstances under which seedings are made: (a) in wheat; (b) in spring-sown small grains or without a companion crop in the spring; and (c) in the summer or fall.

On the basis of the preceding experiments, the following suggestions for obtaining better seedings under these three circumstances are made.

OBTAINING BETTER SEEDINGS WHERE WHEAT IS THE COMPANION CROP

It is usually more difficult to obtain a stand of legumes in wheat than in other companion crops or alone.

1. Apply a top-dressing of manure or straw to the wheat (except on soils of unusually high organic matter content).

a. In the fall or early winter when the ground is dry or frozen and well before the legumes are seeded, apply 4 to 8 tons of manure per acre as a top-dressing on the wheat. Such top-dressings should be made at least to the less productive parts of the field. If the manure is applied in November or December, its protective effect on the wheat will be greater than if it is applied in January or February.

b. One to 2 tons of straw per acre used in the same way as suggested for manure will aid in securing a stand but often reduces slightly the growth and yield of wheat. It is best to apply the straw before January.

2. Most favorable time to seed on wheat:

Meadow crop	Most favorable period for seeding on wheat	
	In northern Ohio	In southern Ohio
Alfalfa	March 15–April 15	March 15-31
Red clover	March–April 15	March
Sweet clover (scarified)	March 15–April 15	March 15-31
Sweet clover (in-the-hull)	February 15–March 15	February
Timothy	At time of seeding wheat	At time of seeding wheat

3. Phosphates stimulate root growth. Where soils are low in phosphorus, an application of 150 to 250 pounds per acre of superphosphate or 0-14-6, made through the drill along with the forage seed, will encourage vigorous root growth and establishment of more seedlings.

4. Coverage of the seed. Forage crop seeds that are slightly covered at seeding time will germinate more satisfactorily and fewer of the seedlings will be killed by freezing or drying than where the seed lies on the exposed surface of the soil. Seed that is broadcast at the earlier dates suggested will normally be covered by the freezing and thawing of the soil and the rains of early spring.

When a soil dries out sufficiently to permit the use of tools during the favorable period for sowing, forage crop seeds are best covered by drilling them in with a grain drill or grass-seed drill or by using a harrow or weeder. Seedings that have been delayed beyond the suggested dates should be covered.

5. Split seedings. This method has been uniformly successful wherever tried. Splitting the seeding increases the cost of making the seeding, but if soil conditions are favorable, the method almost invariably results in a satisfactory stand.

6. Pasturing the wheat. If wheat is tending to make a rank growth, it may well be pastured 10 to 15 days during the last half of April by sheep or cattle. Such pasturing reduces the growth of the wheat and may reduce the yield, but it almost invariably results in better stands of legumes by reducing for a short time the competition between the wheat and the young seedlings of the clovers and alfalfa.

7. Clipping the wheat. If the wheat makes a rank growth and cannot be pastured, it should be clipped about April 20 to 30 in order to give the young legume seedlings a chance to develop.

8. Cutting the wheat for hay. If late May and early June are dry, cutting wheat for hay early in June may save the forage seedings, especially of red clover or alsike clover, by removing the competition of the wheat for moisture. Although lodged wheat may well be cut for hay, the seeding is likely to have been killed before the wheat is removed.

9. Especially for alfalfa, it may be safer not to sow in wheat, but to sow in the summer after the wheat is harvested. If seedings in wheat fail, they may be reseeded or thickened that summer.

10. It is desirable to clip the grain stubble in which alfalfa and red clover are growing during the last 2 weeks of August. Sweet clover is injured by clipping and should not be clipped unless clipping is essential to kill weeds or unless the hay is worth more than its value for soil improvement or pasture the next year.

OBTAINING BETTER SEEDINGS IN SPRING-SOWN SMALL GRAINS, OR WITHOUT A COMPANION CROP IN THE SPRING

1. A firm, well-settled seedbed is desirable, though not as essential as for summer seeding, since there are usually sufficient spring rains to settle the seedbed.

2. Early seeding, as early as the ground is ready to work, is desirable, because there is less danger of drouth; and, since the common legumes germinate at lower temperatures than many summer weeds, early seeding gives the forages a start over the weeds. Where weeds are not a problem, early seeding is still desirable but not essential.

3. The companion or "nurse" crop should be sown at about half to two-thirds the usual rate to reduce both the competition with the forage seedlings and the danger of lodged grain, which might smother the seedlings.

4. Where a less competitive companion crop than grain is desired, and yet because of the danger of erosion it is not desirable to sow alone, 3 to 4 pecks of winter wheat may be sown in the spring as a companion crop.

5. When seeding with spring-sown grain crops, adjust the grass-seed attachments on the grain drill so that the forage seeds are dropped onto the covering chains back of the grain disks (this may require purchasing longer delivery tubes), or else broadcast the forage seed immediately after sowing the grain. Much of the forage seed sown on loose ground is sown too deep.

6. A liberal application of superphosphate or 0-14-6 (250 to 400 pounds per acre) helps the forage seeding, as well as the small grains. Where such an application promotes rank growth of the grain crop, competition of the grain crop with the seeding is often increased.

7. Pasturing the grain companion crop or cutting it for hay may help to save the stand in a dry season, or when the grain companion crops tend to lodge. However, the meadow seeding is often killed before one decides to cut the grain.

8. Sowing alone early on a well-settled, well-prepared seedbed is a very sure method of obtaining stands of meadow crops, where weeds or erosion is not serious.

9. It is desirable to clip the grain stubble in which alfalfa and red clover are growing during the last 2 weeks of August. Sweet clover is injured by clipping and should not be clipped unless it is essential to kill weeds or unless the hay is worth more than its value for soil improvement or pasture the next year.

OBTAINING BETTER SEEDINGS IN THE SUMMER

1. Choose forage crops adapted to summer seeding. Alfalfa is so much better adapted to summer seeding than any other perennial or biennial forage crop that it should always be included in any summer seeding where the soil is at all adapted to it. Red and alsike clovers and timothy are reasonably well adapted; whereas sweet clover does so poorly that it is rarely worth seeding in the summer (Fig. 35).

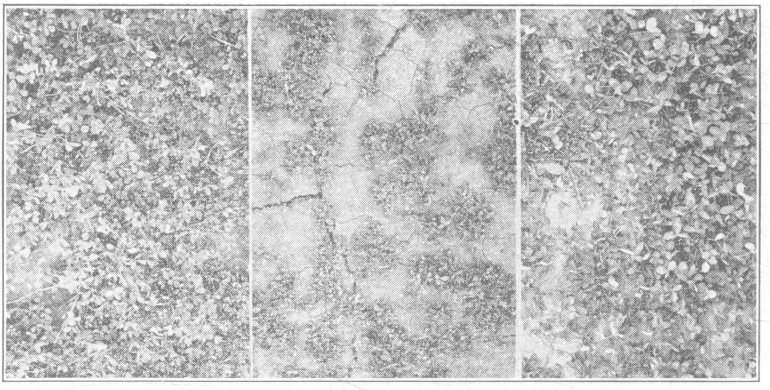

Fig. 35.—Sweet clover is inferior for summer seeding.

Columbus, November 10, 1934. Left, alfalfa; center, white sweet clover; right, red clover, sown August 13, 1934, on fallowed soil. Yield, June 15, 1935, alfalfa, 5170 pounds per acre; sweet clover, 3610 pounds; red clover, 4690 pounds. Alfalfa also made a total of 6840 pounds per acre and red clover, 5500 pounds in the second and third cuttings in 1935.

2. The seedbed should be firm and free of weeds. The seedbed should be prepared by several diskings, or, if necessary to plow, plowed some time in advance of seeding. How long in advance depends on the amount of rainfall received to settle the soil, the weed seedlings to be killed, the possibilities of erosion, and the time of removal of the preceding crop.

In normal or dry seasons, more moisture is conserved by disking than by plowing; in wet seasons, plowing eliminates more of the weeds and volunteer grains.

3. Wait for moisture in the soil. There should be considerable moisture in the soil below the surface 2 or 3 inches, and it is not wise to sow until this reserve moisture is present.

4. No companion or "nurse" crops should be used in summer seeding.

5. In making seedings after small grain is taken off the land, the difficulty with volunteer grain can be reduced by disking the land several times 2 or 3 weeks before seeding or by plowing the stubble.

6. Use liberal applications of superphosphate or 0-14-6 (300 to 400 pounds or more per acre). An advantage of summer seeding is that such applications of mineral fertilizer in the absence of a companion crop will directly benefit the forage seeding.

7. Alfalfa (and sweet clover if sown) should be sown as soon after July 1 as the seedbed is fit for seeding. The clovers may do better if sown after August 1. Latest reasonably safe dates for seeding clovers and alfalfa are August 15 in the northern half of the State, and September 1 in the southern half. Although timothy alone may be sown as late as wheat is sown wherever it is wanted in the meadow mixture, it is better sown at the same time as the legumes.

8. Because the seed drops on firm soil and is covered uniformly, yet not too deep, the following method of seeding is recommended.

a. Prepare a good seedbed, firm below, with an inch or two of loose soil on top.
b. Cultipack.
c. Broadcast the seed.
d. Cover lightly with a harrow or weeder crosswise to the cultipacking.

9. Apply a mulch of 4 or 5 tons of manure or 1 ton of straw at once after seeding. Apply with a spreader, so that a thin, uniform dressing is applied.

10. Mixtures of legumes and grasses will go through the winter better than legumes alone, especially where seedings are made a little late.

11. Do not clip a summer-sown seeding.

THE VALUE OF SEEDING MIXTURES

Especially with regard to obtaining stands, the seeding of mixtures of several crops has definite advantages over pure seedings.

1. The various hazards of seeding do not affect all crops equally, so that a mixed seeding is far more certain to give a stand of some sort of forage than any pure seeding. For example, a mixture containing alfalfa, red clover, alsike clover, and timothy is regularly sown on the outlying experiment farms in Ohio. In 1930, this seeding resulted in practically pure stands of alfalfa; the other crops succumbed to drouth. In certain other years, comparatively little alfalfa has survived, but the clovers have lived and produced hay the next year.

2. Few fields have uniform soil conditions in all parts of the field. Acid and poorly drained spots may result in failures of alfalfa and red clover, but if other legumes and grasses which can endure these conditions are included in the seeding, there will be some hay crop on all the field.

3. Legume-grass mixtures are always preferable to pure stands of grass. The legumes supply nitrogen to the grasses (12), so that they yield more than grasses grown alone (1, 6, 20). The grasses in mixture also contain a higher percentage of protein than grasses grown alone, half again as much in several experiments (20). Frequently, in tests at Wooster, Columbus, and North Ridgeville, the grass in such a mixture has yielded more in the mixture than the same grass has produced grown unfertilized in a pure stand.

4. Grass mixtures protect legumes from heaving on some unfavorable soil types (1, 20).

5. Legume-grass mixtures are more effective in reducing erosion than pure stands of legumes.

6. Legume-grass mixtures resist the encroachment of weeds better than pure stands of legumes (Fig. 36).

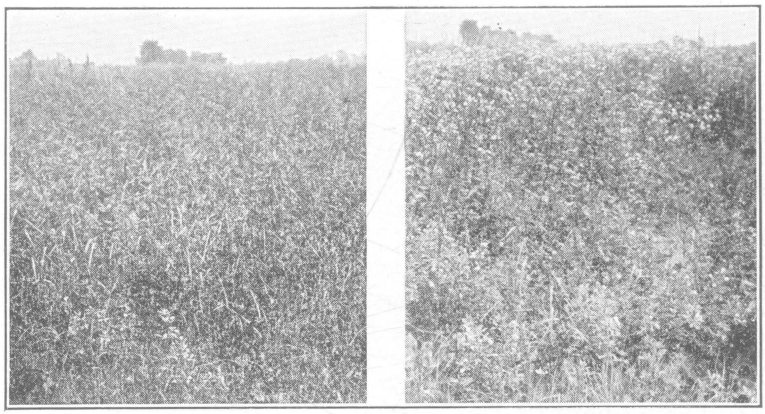

Fig. 36.—Alfalfa-grass mixtures keep out weeds.

Columbus, June 10, 1933. Plots sown April, 1931. Left, alfalfa – orchard grass mixture, no weeds; right, alfalfa sown alone, high percentage of whitetop[9]. These plots are still (1936) standing. No weeds have ever appeared in the alfalfa – orchard grass plot; whereas the pure alfalfa plot has become increasingly weedy.

SUGGESTED MIXTURES FOR VARIOUS SITUATIONS

Alfalfa may be sown as a pure seeding on land well adapted to its culture. Alfalfa-grass mixtures are proving entirely satisfactory for livestock feeders and such mixtures may have a future even on the best soils for alfalfa (1, 6, 20). This is particularly true in view of the present trend toward pasturing alfalfa (3). There is seldom any need for sowing red clover or alsike clover alone except that mammoth red clover and alsike clover intended for seed are best sown alone. Sweet clover intended for a green manure crop the next spring after sowing, or for seed, is best sown alone. For temporary pasture it is generally sown alone, but the sowing of timothy, orchard grass, or some other grass with sweet clover is desirable in order to furnish pasture in the fall of the second year after the sweet clover dies.

In the following suggested mixtures, the pounds per acre of each grass or legume seed to be included in the mixture are indicated.

Legumes are to be sown in the spring or summer, never in the fall, and the amounts suggested are for either date of seeding.

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[9]*Erigeron annuus* (L.) Pers.

MIXTURE NO. 1

Alfalfa, 8 to 10 pounds
Timothy, 3 pounds (fall) or 6 pounds (spring)

This mixture is suggested wherever alfalfa has been reasonably successfully grown alone. The timothy is a valuable addition on many soils, especially those which are a little too heavy for best results with alfalfa alone. The pH range for this mixture is above 6.0 in western Ohio on soils underlaid with limestone, above 6.5 in eastern Ohio. If the fall-seeded timothy does not catch well, more seed can be sown in the spring.

MIXTURE NO. 2

Alfalfa, 6 to 8 pounds
Alsike clover, 4 to 2 pounds
Timothy, 3 pounds (fall) or 6 pounds (spring)

This mixture is suggested for soils which are slightly more acid than those suitable for alfalfa alone, and especially for fields where some areas are too acid for alfalfa but much of the field is not. The pH range is above 5.2 in western Ohio, 5.8 in eastern Ohio. Many think that this mixture cures into a better quality of hay than a mixture like No. 3, which includes red clover. Red clover discolors more rapidly in curing in poor weather than either alfalfa or alsike clover.

MIXTURE NO. 3

Alfalfa, 4 to 6 pounds
Red clover, 4 to 2 pounds
Alsike clover, 2 pounds
Timothy, 3 pounds (fall) or 6 pounds (spring)

This is one of the most useful all-round mixtures. This mixture or modifications of it constitute the standard hay seeding on the outlying experiment farms of the Station (Fig. 37, 38, 39, 40). It is adapted to the same pH range as No. 2, and is particularly worth using as a means of "working into alfalfa", especially on lands in eastern Ohio that have had one reasonable application of limestone, but on which it would be entirely unsafe to sow alfalfa alone.

Under favorable conditions, Mixture No. 3 makes an almost perfect meadow (Fig. 37). There was plenty of alfalfa in this to make a good mixture, as illustrated by Figure 38, which is the second year of the same meadow. This field had a pH of only 5.9. Even on soils which are very poorly drained, and on which alfalfa had been a consistent failure when sown alone, as at the Trumbull County Experiment Farm (1), this mixture has given beautiful, high-yielding, second-year meadows (Fig. 39). Even if areas in the field are so wet or acid that alfalfa fails entirely (Fig. 40), the remainder of the field may yield so much more that the cost of the alfalfa seed is trifling compared to the return from it. This field could never have been considered for alfalfa alone, but the mixture yielded much more than ordinary Mahoning County meadows.

Fig. 37.—A nearly perfect meadow mixture

Belmont County Experiment Farm, May 4, 1934. A beautiful example of the "4-4-2-4" mixture (Mixture No. 3) sown in oats in 1933

Fig. 38.—Second year of an alfalfa-clover-timothy mixture

May 11, 1935. Same field as shown in Fig. 37, now a fine alfalfa-timothy mixture

Fig. 39.—Timothy helps maintain alfalfa on unfavorable soil types.

Trumbull County Experiment Farm, June 14, 1934. Alfalfa-timothy mixture established by seeding alfalfa-clover-timothy on a soil type where alfalfa alone is usually a failure

Fig. 40.—Alfalfa-timothy is superior to timothy.

Mahoning County Experiment Farm, May 8, 1935. Second year of cutting a "4-4-2-4" mixture (Mixture No. 3). Although a few areas, like the foreground, included very little alfalfa, the meadow as a whole is far superior to pure timothy.

MIXTURE NO. 4

Alfalfa, 8 to 10 pounds
Orchard grass, 5 to 8 pounds

This is suggested in place of Mixture No. 1 for the southern part of Ohio where timothy is not so well adapted, and on soils of good to fair drainability with a reaction of pH 6.0 to 7.0. The first cutting of hay must be made early or a poor quality of hay will result. Orchard grass persists much longer than timothy in mixture with alfalfa. Orchard grass can also be used instead of part or all of the timothy in Mixtures No. 2 and No. 3 if it is desired in mixtures for land not uniformly adapted to alfalfa. Orchard grass is best sown in the spring, since the seedlings may winterkill, although it is often successful in fall seedings. The seed cannot readily be sown from a drill, and usually costs two to three times as much per pound as timothy.

MIXTURE NO. 5

Alfalfa, 8 to 10 pounds
Smooth brome grass, 5 to 10 pounds

This mixture, recommended by Joseph E. Wing of Mechanicsburg (21, pages 270-273), and recently extensively tested by the Michigan Experiment Station, promises to be the best alfalfa-grass mixture for pasture purposes, and also makes an excellent quality of hay. It is adapted to any soil which will grow alfalfa, but its adaptation to poor soils is questionable. Brome grass seed, like orchard grass, will not feed through a drill, and must be broadcast.

MIXTURE NO. 6

Red clover, 6 to 10 pounds **Timothy, 3 pounds (fall) or 6 pounds (spring)**

This is the most widely used hay mixture in Ohio at the present time and is valuable for short rotations in situations ranging from very good down to soils of a pH of 5.0. However, red clover will yield decidedly more at pH values higher than this (Table 2), especially in eastern Ohio. This is a good seeding mixture from which to harvest clover seed. Since on adapted soils alfalfa has outyielded red clover even in short rotations (7, Tables 67 and 108), Mixtures No. 1 or No. 3 should often be used instead of Mixture No. 6.

MIXTURE NO. 7

Red clover, 4 to 8 pounds **Alsike clover, 4 to 2 pounds** **Timothy, 3 pounds (fall) or 6 pounds (spring)**

This mixture can be grown successfully on soils of pH above 5.0 and of somewhat lower drainability than can Mixture No. 6 or mixtures containing alfalfa. However, this mixture will also yield decidedly more at pH 6.8 than at pH 5.0 (Table 2).

MIXTURE NO. 8

Alsike clover, 3 to 6 pounds **Timothy, 3 pounds (fall) or 6 pounds (spring)**

This mixture is adapted to still more poorly drained soils than No. 7, with soil reaction at least above pH 5.0.

MIXTURE NO. 9

Alsike clover, 3 to 6 pounds **Timothy, 2 pounds (fall) or 4 pounds (spring)** **Redtop (fancy), 2 pounds (fall) or 4 pounds (spring)**

This is suggested for meadows still more poorly drained than those for which No. 8 is recommended. Alsike and redtop are among the best forages available for meadows on poorly drained land. Reed canary grass also has excellent adaptation to poorly drained land.

MIXTURE NO. 10

Sweet clover (scarified), 8 to 10 pounds **Alsike, 2 pounds** **Timothy, 3 pounds (fall) or 6 pounds (spring)** **Bluegrass, 8 pounds (fall)**

Mixture No. 10 is suggested for establishing permanent pastures on land adapted to sweet clover. Since sweet clover makes a vigorous growth in the second year, it is best to seed the timothy and bluegrass in the fall preceding the sowing of the sweet clover, so that they will be better able to compete with it. Alsike clover can be sown in the spring with the scarified sweet clover. Sweet clover seed in the hull may be substituted for scarified seed and sown in the fall, winter, or early spring at the rate of 20 pounds to the acre. In the year after seeding, sweet clover should be grazed early and closely enough to prevent the

timothy, bluegrass, and alsike clover from being smothered. The sweet clover will disappear after the second summer, with the exception of a few scattered plants coming from hard seeds. Eventually the pasture will consist of good bluegrass with some native white clover and perhaps some sweet clover, depending upon management.

For rotation pastures, the bluegrass, and, if the soil is uniformly adapted to sweet clover, the alsike, may be omitted.

MIXTURE NO. 11

Sweet clover (scarified), 8 to 10 pounds
Alsike, 2 pounds
Orchard grass, 8 pounds (spring)

This mixture is suggested for use in southern Ohio in addition to or in the place of No. 10. Orchard grass is very tolerant of shade, and much more of it than of timothy survives in growing sweet clover. Two pounds each of Korean lespedeza and Japanese lespedeza may be substituted for the alsike clover or used in addition to it. Sweet clover seed in the hull may be sown as suggested in No. 10.

MIXTURE NO. 12

Alfalfa, 8 to 10 pounds
Timothy, 3 pounds (fall) or 6 pounds (spring)
Kentucky bluegrass, 4 pounds (fall) or 8 pounds (spring)

Mixture No. 12 is suggested for the rapid establishment of bluegrass pasture on good soils in western Ohio, or eastern Ohio soils adapted to alfalfa. Both the alfalfa and the timothy will die out under a few years of pasturing, but the carrying capacity of the pasture for the first 4 years will be greatly increased by their presence.

MIXTURE NO. 13

Red clover, 4 pounds or alfalfa, 5 pounds, or a mixture of the two
White clover, 1 pound
Redtop (fancy), 2 pounds (fall or spring on wet land only)
Timothy, 3 pounds (fall) or 6 pounds (spring)
Kentucky bluegrass, 4 to 6 pounds (fall)

This is recommended as a general pasture mixture which can be modified in many ways to meet specific conditions. Alfalfa is more valuable than red clover where it has a fair chance to establish itself. Adapted white clover is a valuable element in pastures, but the value of the imported commercial white Dutch clover is decidedly questionable. Louisiana or Mississippi white clover seed has given best results in Ohio in limited tests of sources of commercial white clover[10]. In the southern third of the State 2 pounds of Korean lespedeza and 2 pounds of Japanese lespedeza may be substituted for the alsike or used in addition to it. Orchard grass may be used instead of part or all of the timothy, and is valuable in pastures including much shade, or on the poorer soils in the southern part of the State. Redtop is worth while only when very wet soils are included in the field to be sown.

[10]Test conducted at the Northwestern Experiment Farm, Holgate.

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